INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER

in this issue:

OCTOBER 1959

Oscilloscope-Camera Recorders 1520
Pressure Recorders 1526
The EDA 1532
Process Control Systems 1535
High Resistance Padded Resistors 1536
Seismograph Structures 1541

PART ONE OF TWO PART ISSUE

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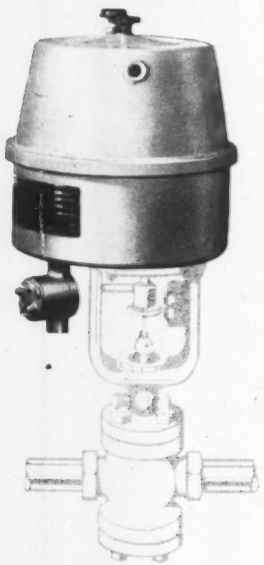

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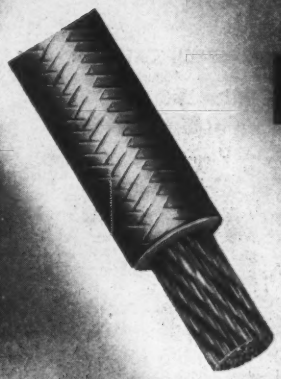

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16	6	00
14	4	000
12	2	0000

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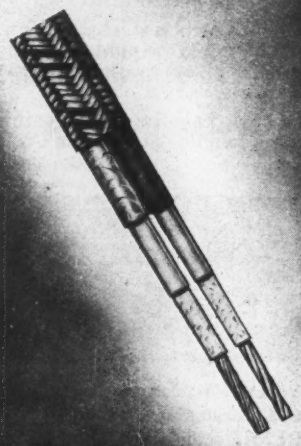

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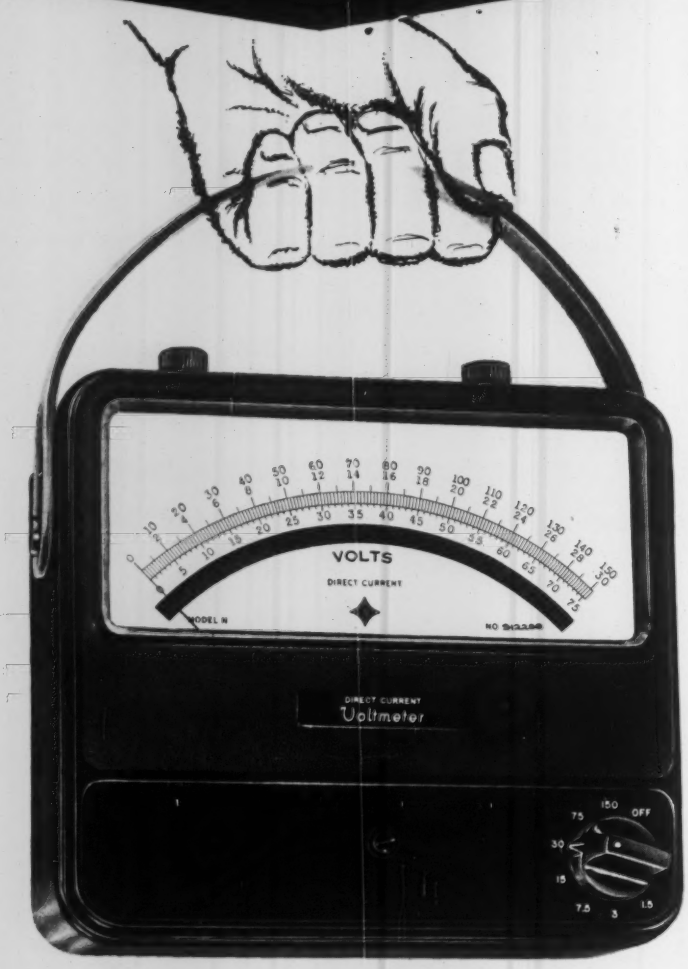
CIRCLE 2 ON READER-SERVICE CARD

SENSITIVE RESEARCH



Model "N"

THE *New* MODEL "N"

A new series of AC and DC portable electrical indicating instruments — *that can also be panel mounted.*

A *New* HIGH in accuracy, resolution, and stability.

A *New* LOW in cost.

In short, the SRIC Model "N" series probably has just the instrument for which you've been looking **HIGH** and **LOW.** The Model "N" is a true "secondary standard" because it is engineered and manufactured by "standards people."

GENERAL SPECIFICATIONS:

Accuracy: .5% of full scale.

Scale: Hand-drawn and mirrored.

Scale length: 6".

Resolution: 100 to 150 division.

Ranges: DC from 50 ua. to 50 A. and 20 mv. to 1000 v. full scale. AC from 10 ma. to 10 A. and 7.5 v. to 750 v. full scale.

Availability: 1 to 8 ranges completely switch-controlled and self contained.

Construction: DC – double pivoted permanent magnet type. AC – moving iron vane for RMS measurements and germanium rectifier type for average reading measurements.

Shielding: Magnetic and electrostatic.

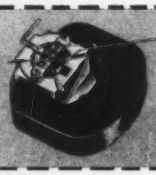
Pivots and Jewels: High carbon steel pivots and shock mounted sapphire jewels. (Diamond pivots available on special order).

Case: Black moulded bakelite with leather carrying handle. Size 7½" x 6¾" x 3½".

The *New* Model "N" is a stable, rugged, versatile field or laboratory instrument that is *spectacular* because in every way it offers a little bit "more" than any other instrument in its class. It is available in standard range combinations or in quantities with special ranges and/or special scale markings.

***The New* Model "N"** *conforms to ASA specs. C 39.1-1951 for .5% class instruments. All SRIC instruments are calibrated against primary standards that have National Bureau of Standards Certificates of Accuracy and are unconditionally guaranteed for a period of one year.*

The movement construction shown features a large size U-shaped magnet with an inherently high torque-to-weight ratio, stability and sensitivity – and *not* the common center core magnet usually found in instruments in its price range.



See SRIC at: Canadian IRE, Toronto, Oct. 7-9
NEC, Chicago, Oct. 12-14
NEREM, Boston, Nov. 17-19

Symbol of Quality

SENSITIVE RESEARCH INSTRUMENT CORPORATION

NEW ROCHELLE, N. Y. ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

CIRCLE 3 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS

Formerly INSTRUMENTS and AUTOMATION

OCTOBER 1959

VOLUME 32 NUMBER 10

PART ONE

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EDITORIAL

Report On Annual ISA Show, 1519

FEATURE ARTICLES

Oscilloscope-Camera Recorders, 1520

SURVEY discusses technique of using cathode-ray-tube and camera recorder for recording signals above 5000 cps

Pressure Recorders, 1526

SURVEY of pneumatic-signal types including static-pressure, differential-pressure and receiver

Ceramics Do The Special Jobs, 1531

INDUSTRIAL ceramics now embrace a wide diversity of materials and can be fabricated in an array of sizes and shapes

The EDA, 1532

JOHN MCLEOD—covers specific advantages, limitations, and cost factors of electronic differential analyzers

Process Control Systems, 1535

FRED D. MARTON—three-element feedwater control via pump and valve

Calibration Of High Resistance Padded Resistors, 1536

R. P. SYKES—technique of measuring resistance ratios accurately and establishing required corrective padding resistor values

Calibration Of Padded-Potentiometer Function Generators, 1539

G. A. KORN—technique uses operational amplifiers to hold one tap of padded potentiometer at a constant potential while adjacent tap is being adjusted

Logger Typewriter, 1540

ADDITION to previous survey of printers

Seismograph Structures, 1541

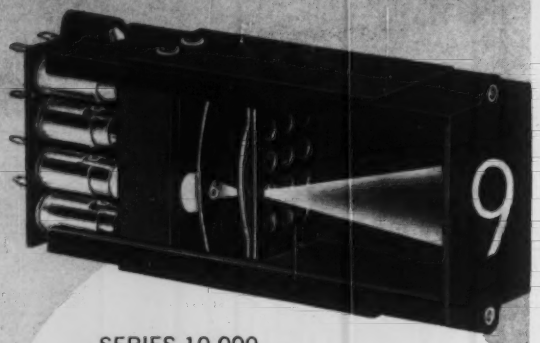
RUDOLPH F. HAUTLY and CARL KISSLINGER—various constructions designed to establish stable reference point with respect to which ground motion can be measured

PART TWO

All-new 1960 **Instruments and Control Systems Buyer's Guide**, listing the products of over 2000 manufacturers of instruments, controls, components, and accessories, is the companion volume to this October issue.

Continued on page 1454

SAVE TIME—MONEY—LABOR



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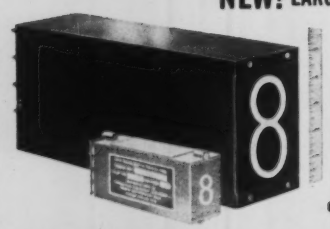

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CIRCLE 4 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS

VOL. 32 No. 10 OCTOBER, 1959

PRINT ORDER THIS MONTH: 33,000

Continued from page 1453

The Journal of THE SOUTHERN CALIFORNIA METER ASSOCIATION

Gas Pressure Regulators, 1544

ROBERT C. LISK—temperature, time and velocity can be used to alter distribution pressure to compensate for pipeline losses and keep delivered pressure reasonably constant.

THE SIMULATION COUNCIL NEWSLETTER

Previewing Program of 1960 Western Joint Computer Conference, 1547
Speed-Regulating System, 1548
Sampling and Quantizing, 1548
Servo Criteria, 1550
Interacting Systems, 1552
Extraction Calculations, 1552

OTHER REGULAR FEATURES

Letters to the Editor ..1456
Trends ..1463
News ..1466
Stock Report ..1472
Events ..1479
Briefs ..1488
Panhandle Pete ..1498
Books ..1503
New Instruments ..1556
Inquiry Card ..1597
New Plants and Mergers ..1588
People in the News ..1590
New Literature ..1592
Searchlite Section ..1593
Employment Opportunities ..1595
Advertisers' Index ..1596
Product Index ..1597

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only CMC makes a

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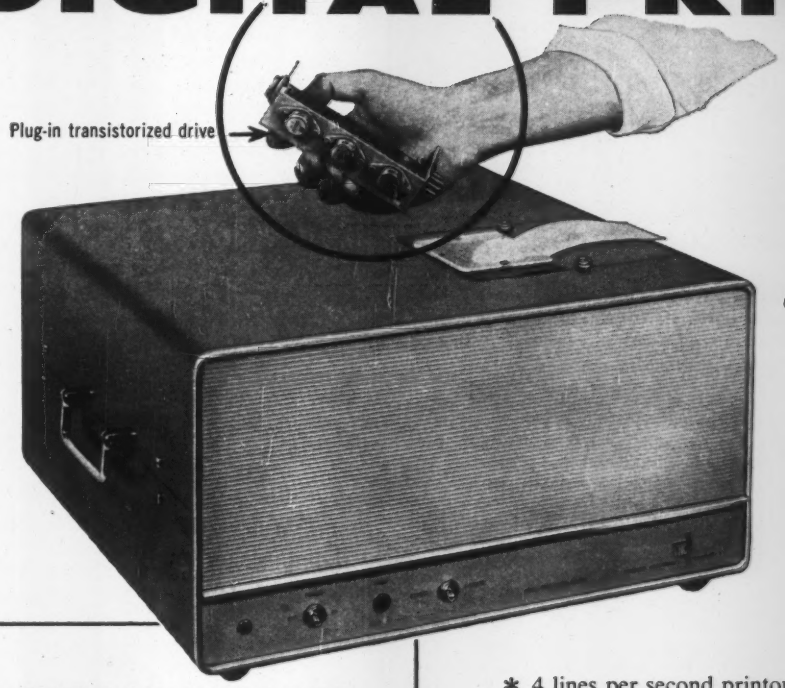

Announcing the 400 CT-

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Warranty	One year on electronics; 1.5 million lines @ 4 lines per second on matrix; 10 million lines @ 4 lines per second on printer assembly, or 1 year, whichever occurs first.
Price	$1350.00. Add $10.00 for rack mount.

* 4 lines per second printout * Takes 1-2-2-4 or 1-2-4-8 four line code * No stepping switches * Operates from only 6 volt input * Parallel entry * Special options available including 10 line and analog output * 6 digit printout, up to 12 digits on special order * Rugged unitized construction * Completely compatible with CMC's new solid state frequency-period counters, and other types of transistorized counting equipment.

For a demonstration of this remarkable new printer and complete technical information, call your nearby CMC engineering representative or write to us direct. Please address Dept. 5510.

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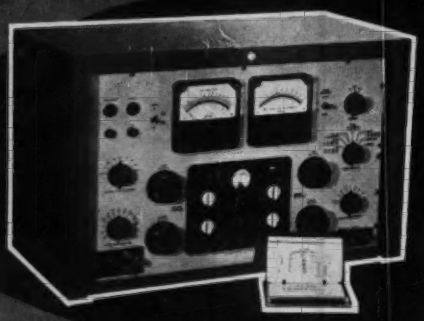
CIRCLE 5 ON READER-SERVICE CARD

from
Instrument Calibration
HEADQUARTERS



The proven method of maintaining Accuracy

Improved reliability and sustained quality control, through periodic calibration of test instruments, can be achieved by semi-skilled personnel using either of these self-contained standards.

Model 829 provides full-scale calibration accuracy of 0.5% for both AC and DC meters over ranges from 0.25 millivolt to 2000 volts and 2 microamperes to 20 amperes. AC calibrations can be performed from 50 to 400 cps., depending on line frequency used, or unit can be driven by optioned variable frequency power supply. Automatic protection for both operator and instrument under test is provided by interlocks and high voltage discharge circuits. Net price $2,650.

Model 829A provides full-scale calibration accuracy of 0.25% for AC and DC meters over same ranges as Model 829. Horizontally mounted standard meters are employed, and a fluorescent light is provided for proper illumination. The illustration shows the Model 829A mounted on the Model 10 Test Equipment Cart with the standard meters recessed into a drop-leaf work shelf. Mounted inside the Cart is the Model 500 Variable Frequency Power Supply which will supply any frequency for calibration from 50 to 400 cps., plus excellent line regulation. Net price of Model 829A with special Weston meters is $3,150.

Performance is rigidly guaranteed. Prices are f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

CIRCLE 6 ON READER-SERVICE CARD

to the editor

Editor, I&CS:

Concerning the article in the June issue entitled "Recording Interferometric Dilatometer", I believe there is an omission. I attempted the modification as it was illustrated and described and found it inoperable.

As it is set up the real image will be found at the exit pupil or eye ring, but the width of the fringes at this point are very much smaller than 1/16" which is the indicated diameter of the entrance pupil to the phototube assembly. In order to obtain the $\cos^2 x$ curve the individual fringes must be at least as wide as the 1/16" diameter hole. Magnification of the fringes, thus, is necessary. A lens of suitable focal length must be added between the eye ring and the entrance pupil. It should be a distance beyond the eye ring that is a little more than its focal length. The correct position of the entrance pupil can also be located. It is now operable.

This adaption has been confirmed by the Gaertner Scientific Company.

David J. Scanlon
Instrument Engineer
Pratt & Whitney Aircraft
Middletown, Conn.

The author replies:

Editor, I&CS:

In reference to the enclosure to your letter of 11 August, 59, the modification to our apparatus, described by Mr. Scanlon is really not necessary. There are two factors which he could have controlled that would have corrected the situation. We believe that the inclination between his two interferometer plates was too steep, giving rise to a larger number of fringes than we used. Also, if he had moved his receiver back farther, magnification of the fringes would have resulted since the Gaertner instrument is already equipped with a suitable lens.

We are pleased with the response to our article.

Irving N. Greenberg
U.S. Army Signal R & D Laboratory
Fort Monmouth, N. J.

Editor, I&CS:

Having been a continuous subscriber to *Instruments*, etc., since 1938, I have all the copies from 1942 —those previous were strung

throughout the Navy. These are invaluable for research or rereading an article, if the date can be remembered. I would like to suggest that additional "Index to Volumes" be made available to subscribers. In this way the volumes can be stacked separately and the indexes filed in sequence in another folder.

Wishing you continued success in the Instruments Publishing Field.

Enclosed is $29.00 for eleven books.

Wilbur E. Statler
Hagerstown, Md.

Editor, I&CS:

I have learned from Mr. Coyle of the U.S. Office of Education that you have developed some excellent courses in the field of instrumentation.

We are presently exploring functioning programs, curricula and current literature in this field with a view to further program development in Wisconsin. We would appreciate information concerning your studies and programs.

Donald M. Brill, Supervisor
Trade and Industrial Education
Madison, Wis.

Editor, I&CS:

The July issue of *Industrial Editor* arrived this morning. I did not put it down until I had finished reading your article "What is the Author Trying to Say?" It was most helpful.

Thanks for your clear, well illustrated sketch of the production and education functions of a technical editor.

Cliff Thompson
Rockwell Manufacturing Co.
Pittsburgh, Penna.

Editor, I&CS:

May I have a copy of the article, "Report on Public High-School Course in Modern Engineering Physics" which appears in the February 1959 issue of *Instruments and Control Systems?*

Robert L. Thing
Instrument Engineering
Mason-Neilan
Norwood, Massachusetts

Editor, I&CS:

Please send me two copies of "Report on Public High-School Course in Modern Engineering Physics."

Seth H. Parsons
New Mexico Highlands University
Las Vegas, Nevada

HAYS LOW RANGE OXYGEN ANALYZER

- for extremely low O_2 ranges (0 to 1%, 0 to 2%, 0 to 3%)
- not affected by H_2 concentrations up to 50%
- accurate to ±2% of range
- sensitive to changes of .01% oxygen
- no moving parts to wear out or break down

Now, Hays—leader in oxygen analysis—brings you a new analyzer specifically developed for measurement of low concentrations of oxygen.

The Model 632 utilizes a new concept of the principle upon which the Hays Magno-Therm Oxygen Analyzer operates—an instrument that has established an enviable record for accuracy and dependability in thousands of industrial applications over a 10 year period. This basic principle is, that oxygen and a few other relatively uncommon gases are paramagnetic . . . i.e., attracted by a magnetic field. This paramagnetic characteristic of oxygen provides an ideal basis for determining oxygen content of gaseous mixtures.

The Hays Model 632 Analyzer incorporates a basic Wheatstone resistance bridge circuit within a recorder to provide a continuous record of Oxygen content by measuring variations in the paramagnetic properties of the sample gas. Complete details of its construction and method of operation will be forwarded on request.

When used with a Hays Model 771 Universal Electronic Recorder and a suitable sampling system, the new Model 632 Oxygen Analyzer provides these distinct advantages:

- Uneffected by hydrogen concentration up to 50%
- Sensitive to changes of .01% oxygen
- Zero stability within ±1% of range
- No moving parts to wear out or break down
- Three available ranges—0 to 1%; 0 to 2%; 0 to 3%
- Divided flow assemblies significantly reduces possibility of cell damage due to dirty or wet sample gases passing through analyzer
- Accuracy better than ±2% of range
- Extremely fast response to fluctuation in oxygen content

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Boiler Panels • CO_2 Recorders
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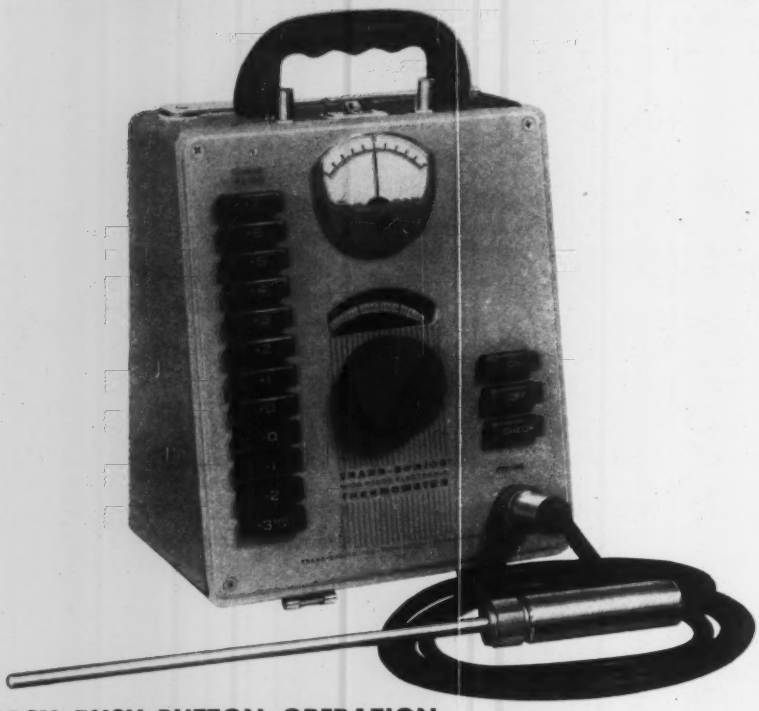

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RANGE OF −425 TO +800F.

Now you can measure temperature quickly, easily and accurately over a wide range with full interchangeability of probes and indicators. In this new Electronic Thermometer the circuit is transistorized to provide maintenance free, dependable operation. A platinum temperature sensing element is used in the Probe for long-term stability.

- **Accuracy with interchangeability: ± ½ F.**
- **Power: 110 volt, 60 cycle or self-contained batteries.**
- **Weight: 12 pounds with batteries.**
- **Dimensions: 10½" x 9" x 6".**
- **Probe: 9½" long, ⅜" diameter. Welded stainless steel. Proof pressure 4,000 psia.**

Write for Technical Bulletin 140 to Trans-Sonics, Inc., Dept. 16, Burlington Mass.

TRANS-SONICS T.M.

Precision Transducers

CIRCLE 8 ON READER-SERVICE CARD

LETTERS—CONTINUED

Editor, I&CS:

I have read your article "Weight" in the December 1958 issue. In your Table 3 you list various drifts in steel. Also previously you mentioned a hysteresis effect in spring steel. These figures seem excessive in view of the results we have had here when working with tool steel.

We would appreciate receiving your original source of information . . . the original test data in question.

We have done a considerable amount of work here developing a differential transformer type of load cell to be used with our storage tanks. It was thus with a great deal of interest that we read your very fine article. We know this must have taken a great deal of research, and we believe it was very well presented.

J. A. Perry
Manager, Automatic Controls
Cherry-Burrell Corp.
Cedar Rapids, Iowa

The spring-steel data are averages for hard drawn, music, oil tempered and high-carbon steels. The latter would show the least hysteresis, less than that indicated in the table.

Editor, I&CS:

The reprints of Mr. Moeller's article "Welding a Thermocouple Junction" arrived in good shape. We have received more than a dozen requests. So obviously *INSTRUMENTS AND CONTROL SYSTEMS* has excellent readership among people interested in this field.

I hope we will have another suitable article sometime soon in which case I will surely shoot it along to you.

Odom Fanning
Midwest Research Institute
Kansas City, Mo.

Editor, I&CS:

As a school board member, reasonably active from local to national levels, I was much interested in your "Anti-Hardwarism . . ." editorial in March *I&CS*. (I am going to ask our librarian to get your February issue, which for some reason is missing). This is a pungent item.

I like your approach. (I happen to be an elementary board member —but am on several state committees, including an alumni advisory committee, because I contend the University should articulate to Elementary Junior High on motivation and follow up problems.) We have

had a special mathematics laboratory, in one of our three elementary schools, using some laboratory techniques for aids in teaching Math. at 7 and 8th grade levels, with a few trials down to the 4th grade.

Is it possible that the "Vocational" tinge you report is the result of instruction rather than "hardware"? Perhaps "hardware" is like the passive book, up to now the greatest aid to education, or like E.T.V., a medium that allows the really better instructor to do a better job for many many more students. "Electronic Aids to Education" (my penchant), are passive but revolutionary in the hands of the superior teacher.

How does the achievement of your students compare as matched pairs?

Your article is very fine. Perhaps you have some ideas on instrumentation-learning-motivation at the Junior High Elementary level in education, where I believe the real scientists and engineers are first made, and where students develop the real love and joy of learning, intangible as it is.

I was pleased to see what I thought was a good educational article in a non-educational magazine. It was indeed well done, and I hope more educators will see it.

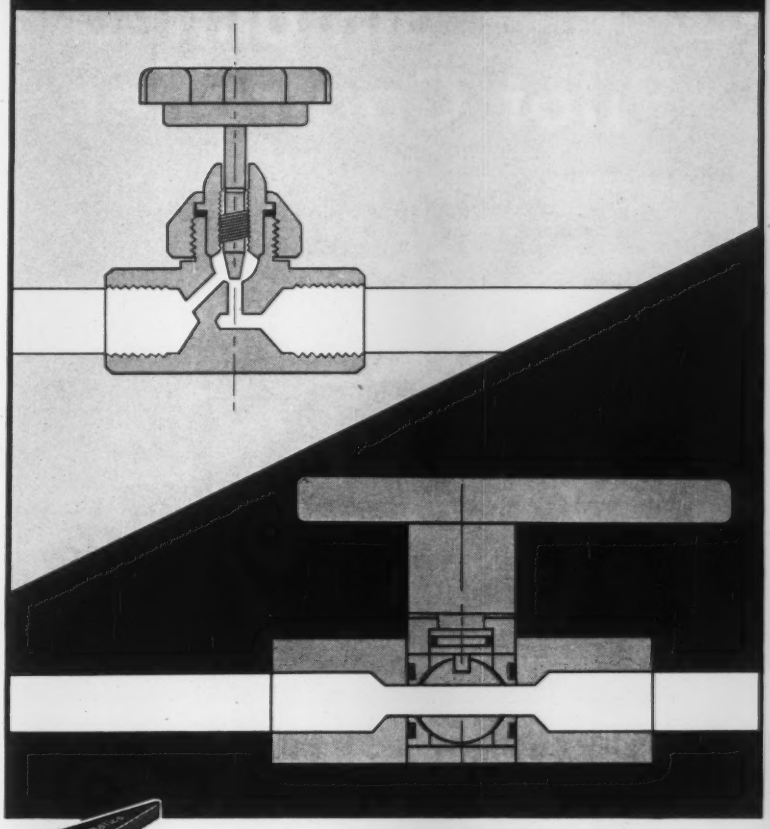
Lloyd P. Morris
Motorola, Inc
C&IF Division
Chicago, Ill.

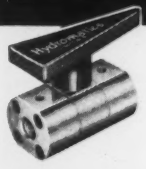
As the students in the class were of high IQ, any comparison with other students is difficult to assess. These students volunteered to travel across a city twice a day to take 2 extra hours of academic instruction per day—in addition to their regular academic program. One would expect them to do well anywhere. However, the reaction of the students, lecturers, and teacher (particularly) are meaningful; they are included in the Report.

As to fundamentals—the equipments and hardware were used only to show practical examples of modern fundamentals at work, and only after the fundamentals were covered by teacher and lecturers. This type of motivation is essential at the high-school level, where increasing percentages of students are being repelled from, rather than attracted to, science and engineering.

We agree that the problem of student motivation occurs below the level of the college—but the colleges, who control high-school curricula, don't know it. Use of instrumentation (hardware) is one of the most effective motivation practices at all levels.

FLO·BALL 715
makes needle valves obsolete





Which valve has 100% flow efficiency?

100% flow efficiency — an unrestricted straight-thru fluid path — is another feature of the Hydromatics ***FLO•BALL 715***, shown on the bottom. That's more than **double** the flow efficiency of needle valves. Furthermore, a fast quarter turn moves the ***FLO•BALL*** from open to closed position; instant action at flow pressures up to 3,000 psi with just 4 inch-pound torque! And the arrow-shaped handle provides positive on-off indication.

Ideal for leakproof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, etc., the ***FLO•BALL*** features zero leakage, universal mounting, removable flanges, and all stainless steel construction.

Write today for a complete catalog describing this valve and others for corrosive and cryogenic media. Also special designs for throttling flow control.

The *FLO•BALL* costs no more than old fashioned screw-type valves!

Exceptional engineering employment opportunities—write today!

Hydromatics, Inc.

LIVINGSTON, N. J. • WYMAN 2-4900 • TWX = LIVINGSTON, N. J. 120

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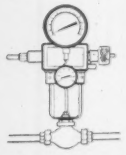
CIRCLE 9 ON READER-SERVICE CARD

Remote Control of Temperature or Pressure with TRUE Proportional Band Adjustment

Now, the simplest *true* proportional band adjustment in the field . . . a compact, inexpensive unit for positive remote control of temperature or pressure in countless applications. Fast-response bulb sends three- to fifteen-pound air signal to control valve, damper actuator or other control device. Long-life dependability ends pilot control headaches. Available as "blind" or indicating controller.

- Convenient knob adjustment
- Low air consumption
- Small, highly sensitive element
- Simple field reversibility
- True proportional response
- Any 50° range, —20° F. to +380° F. Pressure: 3-35 psi; 5-75 psi; 15-150 psi.



Can be supplied factory mounted on control valve

FOR COMPLETE INFORMATION, WRITE FOR BULLETIN TL-113

Robertshaw-Fulton
CONTROLS COMPANY

FULTON SYLPHON DIVISION • Knoxville 1, Tennessee

CIRCLE 10 ON READER-SERVICE CARD

Editor, I&CS:

Could you please explain what the diagram used to head the Simulation Council newsletter in your magazine is intended to represent. In our instrument shop here we are of differing opinions as to whether it represents a control system, a process, or a combination of both. What the individual symbols represent, is also a mystery which you might clear up for us.

B. W. Littlejohn
Ocean Fall B. C.
Canada

Editor, I&CS:

As a regular reader of *Instruments and Control Systems* I shall be highly grateful if you kindly let me know the details and the American Universities for which I have to apply to get a Doctorate or Master's degree in Instrument Technology.

Regarding my educational qualifications let me state briefly that I passed the B. S. C. Degree examination of the Madras University (India) in the year 1952 with physics as main subject and mathematics and chemistry as subsidiaries. Further I have taken the post-graduate diploma of the Madras Institute of Technology (D.M.I.T.) in Instrument Technology in the year 1956. This is a three year course after graduation and comprises theory, design, calibration and maintenance of various types of Electrical Mechanical, Industrial, Optical, Electronic, Air-craft, Time-measuring, etc. instruments. Also I am a member of the "Society of Instrument Technology" (London). I am now working in the Instrumentation department of the Central Fuel Research Institute as a scientific assistant for the last 22 months.

L. J. Krisnamurthi
Central Fuel Research Institute
Jealgora P. O.
Dhandat dt.
Bihar, India

Editor, I&CS:

Do you have reprints of your editorials on education published in February and March entitled: "Report on Public-High-School Course in Modern Engineering Physics" and "Anti-Hardwarism?" If so, may I have a copy of each?

They are *good*.

J. W. Krewson
Instrument Department
Oak Ridge National Laboratory
Oak Ridge, Tennessee

In the December, 1955 issue of this publication, we reported that Dr. Jerrold Zacharias and colleagues at the Massachusetts Institute of Technology had developed the first atomic clock. Subsequently we reported the several developments of this clock, including its production by the National Company of Malden, Mass.

Hence we were startled to discover that the Soviet Union awarded its Alexander Popov Gold Medal to Dr. Louis Essen of the British National Physics Laboratory, for Essen's work in establishing an atomic frequency standard. We have asked Dr. Zacharias to clarify this situation, and Dr. Zacharias responds as follows:

Editor, I&CS:

You are right to be confused by the recent award to Dr. Essen. The facts are simple. Some colleagues and I, in fact, made the first atomic clock. That clock has subsequently been put into production by the National Company of Malden Massachusetts, and they have sold a great many. At the present time they are, without question, the most precise clocks in the world—more precise than Essen's or anybody else's. But Essen had one other very important thing. He has access to the frequency control station of the National Physical Laboratory, which frequency was compared directly with astronomical timing. We did not have that frequency in our laboratory because the American equivalent is maintained in Washington, D. C., and that is not near enough to Cambridge, Mass., for a direct comparison.

Before Essen started his work with cesium clocks, he made a tour of this country and spent some time at my laboratory. His own clock was made after studying what other people in this country were doing.

None of this is adverse to Essen's accomplishment. His work is serious and extremely good . . . This letter has been written merely to clarify the situation.

Jerrold R. Zacharias,
Massachusetts Institute of Technology
Cambridge, Mass.

Where
high Performance
is vital, specify...
BREEZE BELLOWS
Because BREEZE Bellows are job engineered for the most exacting applications, they insure high performance and long life. BREEZE offers a wealth of experience in weldable alloys such as Iconel X, titanium, Ni-Span, Hastelloys and Stainless steels. BREEZE Bellows solve tough problems in instrumentation, fuel regulation, pressure switches and expansion joints, hot air ducting, pressure surge tanks, packless valves, oscillating and rotating shaft seals, atomic and nuclear reactors.
We invite your inquiries.
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BREEZE PRODUCTS: ACTUATORS • HOISTS • TRANSMISSIONS • GENERATORS • STARTERS
STARTER GENERATORS • BELLOWS • SLIP RINGS • HOSE CLAMPS • HITEMP FLEXIBLE TUBING
CIRCLE 11 ON READER-SERVICE CARD

reader inquiries

Hardening by Induction Heating High-Temperature Control

Vice president (R & D) of photographic equipment manufacturer seeks contact with manufacturers of equipment for (1) hardening of steel by induction heating, and (2) electronic control of high temperatures. A-430

Pressure Gage Movements

Research associate in University aeronautical lab wishes to buy pressure gage movements. A-431

Semi-Conductor Test Equipment

Manufacturer of components using semi-conductors seeks test equipment. A-432

Metal Locator

Engineer in Brazil wishes to contact manufacturers of metal locators. A-433

Thermocouples for Nuclear Reactor

Instrument engineer on experimental nuclear project wishes to receive information on operable thermocouple installations in nuclear reactors. A-434

DEKORON ARMORED INSTRUMENT HARNESS

4 + 4 = 16

TUBE MATERIALS + TUBE CONSTRUCTIONS = DIFFERENT TYPES

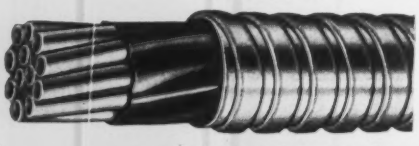
Yes, *four* different core tubing materials (copper, aluminum, polyethylene, nylon) combined with *four* distinct types of armoring give you *sixteen* different types of Dekoron Armored Instrument Harness from which to choose.

Designed specifically for instrument harness application, special Moore-Loc armor construction has almost twice the pull-apart resistance of ordinary armoring . . . has cord packing for extra resistance to moisture and fume penetration.

There's at least one best type of Dekoron for your installation. We help *you* select it; we're unbiased because we make all types. Now go Dekoron 100% for all your tubing needs. Think of Dekoron first . . . to last. That's *Dekoron—America's Premier Line of Armored Instrument Harness.* A-314A

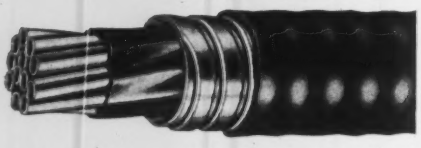
CONSTRUCTIONS

TYPE VA



For Impact and Corrosion Resistance. Core tubes with vinyl sheath covered with Moore-Loc modified-square-lock construction armor with cord packing.

TYPE VAV



For Impact and Maximum Corrosion Resistance. Same construction as Type VA (*above*) but with outer vinyl sheath. 24-gauge galvanized steel armor gives maximum pull-apart and impact resistance.

TYPE A

For Impact Resistance in Dry Locations. Core tubes are wrapped in vinyl-impregnated insulating tape. Tape insulates and cushions core tubes inside metal armor.

TYPE AV

For Corrosion and Impact Resistance. Same construction as Type A (*above*) but with outer vinyl sheath. All four constructions available with metal or plastic core tubes.

Dekoron® products QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION • MANTUA, OHIO

CIRCLE 12 ON READER-SERVICE CARD

trends

Market for silicon solar cells is now about $4.5 million annually, but should increase 25 times by 1970, says R. F. Edwards of International Rectifier Corp.

Industrial commercial electronics market was $676 million in 1950, $2.46 billion in 1959, may reach $6 billion by 1970, says H. Hoffman of Hoffman Electronics. Also, present $4.5 billion military electronics market may reach $10 billion by 1970. Parts, repairs and services market is now $2.6 billion; may reach $3.6 billion by 1970.

Japan enters computer field, with 50 computers to be made in 1960, 100 in 1961, 50 more each succeeding year.

Space electronics market in 1959 is $200 millions, says A. D. Little.

Officials of Air Material Command state that 163 bases will be equipped under a six-million-dollar Air Force precision measurement and repair program. Laboratories already are operating at most missile bases. Precision calibration laboratories will be in operation at most large Air Force bases by end of 1959.

A 23.5% increase in corporate aid to education over the two years from 1956 to 1958 was revealed in a survey of the country's 1,500 largest corporations released by the Council for Financial Aid to Education. The gains were noted in a control group of 215 companies which reported grants to higher education in both years, totalling $33,140,806 in 1956 and $40,917,571 in 1958. The highest average gift per company was in the electrical machinery field, with 11 companies averaging $336,366 in educational grants for 1958. Chemicals were second, 25 companies averaging $247,371 apiece. Tobacco was third, 3 companies averaging $247,353 apiece.

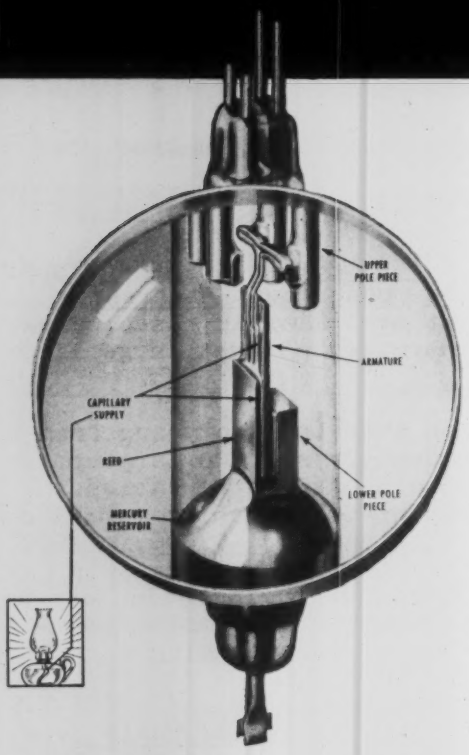
U. S. precision instrument manufacturers continued to expand their oversea market during 1958, reaching a new sales peak of approximately $231 million (in contrast to $217 million in 1957, $164 million in 1956, and $128 million in 1955) reports BDSA, U. S. Department of Commerce. Indicating, measuring and control instruments represented four-fifths of the oversea sales, or $185 million ($114 million were mechanical measuring type; $42 million geophysical, navigational, nuclear and related instruments; $29 million electrical measuring; scientific, research and engineering instrument group $46 million, including laboratory equipment of $24 million, optical $11 million, horological $8 million, and surveying instruments $3 million). Note: only laboratory, optical and horological oversea sales declined—due to European and Japanese competition.

Ten largest oversea Instrument markets, says BDSA, were Canada $66 million; Venezuela $17 million; Mexico $10 million; Brazil $8 million; Cuba $4 million; Japan $17 million; France $10 million; Germany $9 million; Italy $9 million; and United Kingdom $7 million. Australia, Netherlands, Sweden, Belgium, and India each purchased from $3 to $4 million U.S. instruments last year.

Over 8 billion* operations

CLARE Mercury-Wetted

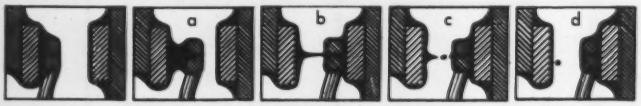
*with contact load of 250 volt-amperes.



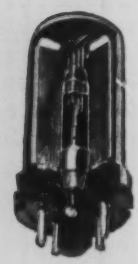
NEVER WEAR OUT

Longevity is built into these relays. The basic magnetic switch is sealed in a glass capsule filled with pressurized hydrogen. With every make and break the mercury-film contact surface is renewed . . . by capillary action, like a lamp wick. These contacts never get dirty, never lock or weld and *NEVER WEAR OUT.*

NEVER CHATTER OR BOUNCE

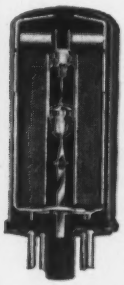


Contact closure between the two liquid surfaces bridges any mechanical chatter and prevents its appearing in the electrical output. (a) Filament of mercury forms between the contacts as they separate. (b) This becomes narrower in cross section and (c) finally parts at two points, allowing a globule of mercury to fall out. (d) The extremely fast break minimizes the arc and adds greatly to contact load capacity.

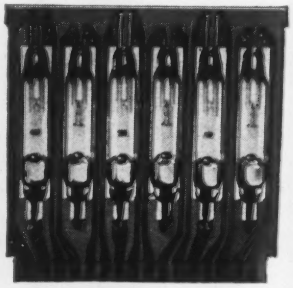


NO MAINTENANCE REQUIRED

HG Relay cutaway to show magnetic switch surrounded by operating coil and encased in a metal housing.



HGS Relay cutaway to show biasing magnets attached to the ends of the side plates.



HG6F Relay printed circuit panel showing six in-line mercury-wetted contact switches mounted in minimum space.

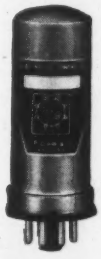
With all working parts sealed and switches and coils enclosed in metal housings, these relays are tamper-proof and always in constant adjustment. They require no maintenance whatsoever.

CIRCLE 13 ON READER-SERVICE CARD

–with no maintenance!

Contact Relays on test 4 years

A FULL LINE OF THE MOST RELIABLE, MOST DURABLE RELAYS EVER MADE

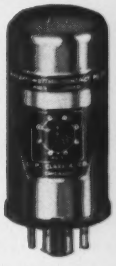


single form D

Type HG. Capable of up to 100 operations a second. Load-handling capacity to 5 amperes and up to 500 volts. (250 va max. with proper contact protection.)

single form D

Type HGP. Can be factory adjusted to provide single side-stable, bi-stable or chopper characteristics.



single form D

Type HGS. Biased with permanent magnets. Speed up to 200 cps. Sensitivity as low as ±2.5 milliwatts. Handles up to 2 amperes, up to 500 volts (100 va max. with proper contact protection.)

four form D

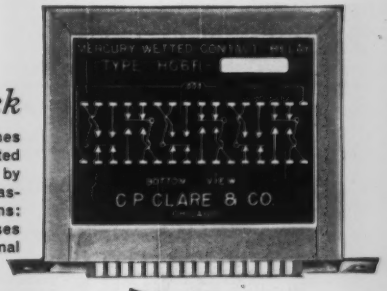
Type HG4. Four form D switches enclosed in a single housing with coil. Plug-in assembly (shown) is standard. Other mountings available.

two or three form D

Types HG2 and HG3. Two or three form D Switches enclosed in a single housing. HG2 has 8 or 11-pin octal style plug. An 11-pin base is standard for HG3.

six in-line flat pack

Type HG6F. Six switches mounted in line on printed circuit panel surrounded by single coil. Flat, compact assembly. Over-all dimensions: 3.640" x 3.125" x 1.046". Uses standard 32 or 36 terminal printed circuit socket.



For complete information on CLARE Mercury-Wetted Contact Relays or on the entire CLARE line of superior relays and electronic components address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Limited, P. O. Box 73, 2700 Jane Street, Downsview, Ontario. Cable Address: CLARELAY.

Send for Catalog 201

CLARE RELAYS

FIRST in the Industrial Field

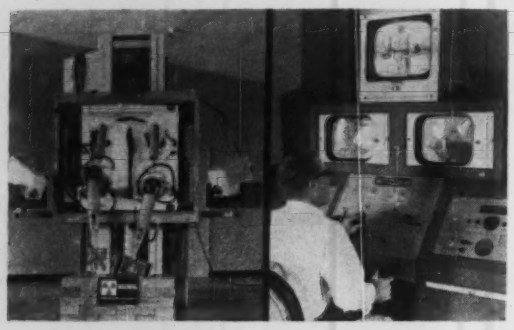
CIRCLE 13 ON READER-SERVICE CARD

news

Mobot Makes its Bow

LOS ANGELES, CALIF.—The Mobot Mark I is a combined manipulator and mobile cart, all controllable from a remote location.

Developed and built by Hughes Aircraft Co. for the Sandia Corp., direct contractor for the AEC, the mobile Mobot Mark I can find an item to be tested, carry it into a radiation lock, then "walk" back to its "hot" lab. Mobot can perform a variety of lifting (up to 150 lb



with either arm) inverting and placing operations, comes equipped with 200 ft of cable for wide-ranging maneuverability and can pick up and use auxiliary tools such as wrenches, screwdrivers, hammers and shears for dismantling radioactive material.

Mobot's "pilot" sits safely in another area behind thick concrete where he has no direct view of his "slave" and directs the mobile robot's movements by ITV with pistol-like grip controls that form electronic "reins." A microphone "ear" on Mobot permits the operator to hear its metal fingers grasp an object at the same time he sees the hands clutch it.

William Henry Pugsley

William Henry Pugsley died August 11, 1959, 57 years old, a victim of cancer. For the last twenty-seven years he was a vice president of Hays Corp. in charge of Field Research.

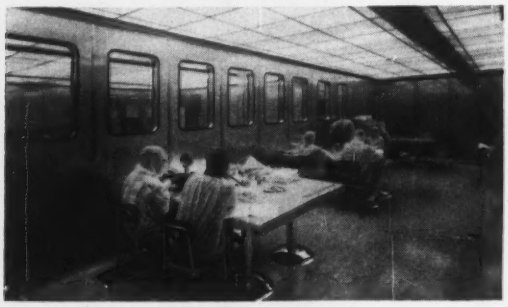
During World War II, in 1943 and 1944, Bill was on loan from the company to the War Production Board as a Dollar-a-Year specialist of the instrument industry.

Bill Pugsley was also well known through his activities and lectures in the ASME and the ISA, and he leaves many friends behind whose esteem he had won by his civic activities.

Mr. Pugsley is survived by his wife Annie White Pugsley, their three children, and two grand children.

White-Room Efficiency Report

BIDDEFORD, MAINE.—Baker Co. which had erected a white room (shown in picture) for Sperry-Farragut Co., Bristol, Tenn., to protect the assembly operations of ball bearings from air contaminants, recently published a report which Armour Research Foundation had been called upon to write on the effectiveness of the measures taken.



With the aid of the ARF particle counter (which counts single particles by using scattered light pulses) it was found that the total concentration of material in the room increased with the amount of activity—i.e., the number of persons present and the type of operation in the room. The highest concentration amounted to 500 particles/liter, and the largest particles were on the order of 32 microns in dia. They were traced to lint from clothing and abrasion products as the main offenders. However, when the room had been cleaned carefully, no more than 330 particles/liter, ranging in size up to 4 microns were found.

DAYSTROM SYSTEMS DIV. has designed new equipment to translate large amounts of process or test data into digital form for transmission over standard telephone circuits. This technique eliminates the requirement for computer equipment at the job site. A large system handling 2000 individual measurements of temperatures, pressures, and flow rates has already been delivered by Daystrom Systems to a major nuclear facility.

IAEA, the International Atomic Energy Agency, recently held a five-day conference in Warsaw, Poland, which was devoted exclusively to the role of ionizing radiation in industrial processing.

REMINGTON RAND has released the new Univac Tape Searchwriter, an integrated system which provides an economical method of searching a magnetic tape file for a desired item and then automatically typing the information or punching it into tape.

RAYTHEON AND BOSTON UNIVERSITY have announced jointly an evening graduate school program leading to the M. A. and Ph. D. degrees in physics. It is believed to be the first industry-sponsored program whereby a graduate degree in physics can be earned after working hours.

FARRINGTON MFG. CO. has received a patent covering two new approaches to character recognition problems which make it possible to recognize a character regardless of where it is positioned as long as it is entirely within the scanning field.

New Money Makers for Industry:

KIN TEL CLOSED CIRCUIT TV SYSTEMS

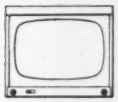
what they are, and what they can can do for you...

What is a KIN TEL Closed Circuit TV system?

The basic closed circuit television system manufactured by KIN TEL consists of a camera, a camera control unit and a monitor (receiver) each connected by cable. The camera can be located at great distances from the monitor, and any combination of cameras and monitors can be used.

The camera is small enough to hold in your hand; rugged enough to operate in 150° F. without a protective housing; sensitive enough to provide excellent pictures of objects illuminated by only a candle.

The camera control provides automatic operation. The system is continuously self-adjusting for wide variations in light levels (several thousand to one), and features automatic high definition of bright objects. The only control you have to touch is the on-off switch.

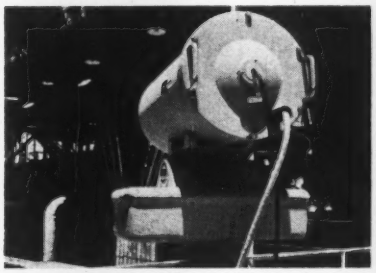


The monitor displays a crisp, clear picture...full 650-line resolution, twice that of the best home TV reception.

How are such systems used?

Today, KIN TEL closed circuit TV systems are performing a number of jobs for *hundreds* of firms, safely, inexpensively, tirelessly.

They are being used to watch operations or events that are tedious, difficult, dangerous, or even impossible for men to watch.



For example: Convair (above), Douglas, Lockheed and Northrop watch rocket tests with KIN TEL systems. U.S. Steel uses one to see inside open hearth furnaces. Westinghouse watches nuclear power reactor tests with one.

They are being used for surveillance.

For example: The San Francisco Naval Shipyard uses one to guard against pilferage.

They are being used for traffic control.

For example: The Alameda Naval Air Station uses a KIN TEL TV system to observe aircraft landings on the portion of the runway that is not visible from the control tower.

They are being used to transmit visual information quickly and accurately; for remote observation of charts, meters, graphs, schedules, blueprints, photographs, images from microscopes, fingerprints, signatures...the list is almost endless.

For example: E. F. Hutton uses a KIN TEL system to transmit stock market quotations to the offices of the firm's executives. The Los Angeles Department of Water and Power uses one for remote viewing of water-level meters. The University of California teaches physics with one.

They are being used for monitoring any operation that normally requires standby personnel.

For example: American Potash and Chemical (above) monitors conveyor line and warehousing operations with a KIN TEL TV system.

Why do these firms choose a KIN TEL system?

For a variety of reasons.

First, *reliability.* KIN TEL TV is designed for continuous duty operation in severe environments. Day in and day out, it keeps working. It's the first choice for ICBM and other missile programs that really depend on TV, that can't chance failure, that can't afford to compromise with reliability.

Second, *picture quality.* KIN TEL TV presents clear, sharp pictures. Full 650-line resolution provides maximum data...essential for *quantitative* observation of complex operations or transmission of printed material.

Third, *automatic operation.* KIN TEL TV is the only closed circuit system that provides entirely automatic, through-the-lens compensation for light-level changes of several thousand to one.

Fourth, the KIN TEL closed circuit TV system is extremely *sensitive.* The light required to read this page is enough for sharp clear pictures, and usable pictures can be provided with less than one-foot candle illumination.

Fifth, KIN TEL TV systems are *easy to install* and *simple to operate.* With no changes in lens iris to make, with no difficult, interacting electrical adjustments required, the only thing the operator has to know is the location of the on-off switch.

Sixth, a *complete* line of shelf-item system components and a variety of cameras and monitors make virtually any application feasible...permit observation of nearly every kind of operation, under all kinds of conditions.

For example, with system components, you can remotely position the camera, remotely select one of several lenses, remotely "zoom" in or out for closeup or wide-angle viewing, operate the camera in extremes of temperature or in explosive or dusty atmospheres, view microscope images. Whatever your viewing problem, KIN TEL probably has a *stock* solution.

Seventh, you don't have to waste your time and money on application engineering. At no obligation to you, KIN TEL's nationwide factory-trained field engineers – thoroughly experienced in optics, environmental requirements, lighting, cabling, human engineering factors, and other installation considerations – can determine whether or not closed circuit TV can be put to profitable use in your intended application.

What can a KIN TEL system do for your business?

It can do what it is doing right now for hundreds of other firms. It can save you time and money...increase efficiency...better your service to clients and customers. To find out how, write direct for catalog 6-103 and the name of your nearest KIN TEL engineering representative.

KIN TEL
A DIVISION OF
COHU
ELECTRONICS, INC.

5725 Kearny Villa Road, P. O. Box 623, San Diego 12, California, BRowning 7-6700

KIN TEL – pioneer and leader in closed circuit television.

CIRCLE 14 ON READER-SERVICE CARD

YOUR POTENTIOMETRIC INSTRUMENTS

NO matter how perfect otherwise, the human organism isn't much good without a dependable heart. The same is true of your automatic temperature and pH control instruments.

The "heart" of most such instruments for the past quarter century has been the Eplab Standard Cell. It is a "yardstick" for translation of voltage to temperature or pH. The first American commercial cell of its type, constantly improved by research, it is "as standard as sterling".

Get ACCURATE temperature or pH control with potentiometers and make sure the standard cells are EPLAB.

The Eppley Laboratory, Inc. 2 Sheffield Ave., Newport, R. I.

EPLAB *Standard* CELLS
FOR POTENTIOMETRIC INSTRUMENTS
"As Standard as Sterling"

CIRCLE 15 ON READER-SERVICE CARD

NEWS —CONTINUED

LEEDS & NORTHRUP has received a second Navy contract covering electronic recorders to be installed at the U. S. Naval Air Rocket Test Station at Lake Denmark, Dover, N. J.

At an April ASC meeting, **PERKIN-ELMER** reported results of gas chromatographic analysis of alcohol beverages, showing how very small amounts of congeneric materials are responsible for flavor, odor and hangover effect. Story hit national wire services; result: Perkin-Elmer has been bombarded with requests for whisky extracts and whisky flavors, and congratulated for its fight against alcoholism.

APPALACHIAN GAS MEASUREMENT SHORT COURSE, August, West Virginia University, recorded the largest attendance in nineteen years.

A STRESS MEASUREMENT SYMPOSIUM will be held January 1960 at Arizona State University featuring lectures and exhibit. For more information write to "Strain Gage Readings," 5602 East Monte Rosa, Phoenix, Arizona.

VINCENT E. LYSAGHT, general sales manager of Wilson Mechanical Instrument Div., American Chain & Cable Co., represented the United States as featured speaker at the Third International Work Conference, Sept., Dortmund, Germany. Theme of meeting was "Hardness Testing in Theory and Practice."

Statement of Ownership, etc.

Statement required by the Act of August 24, 1912, as amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233) showing the Ownership, Management, and Circulation of

INSTRUMENTS & CONTROL SYSTEMS

published monthly at Pontiac, Illinois for October 1, 1959.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Richard Rimbach, 8550 Babcock Blvd., Pittsburgh 37, Pa.; Editor, Milton H. Aronson, 4800 Stanton Avenue, Pittsburgh, Pa., Managing editor, F. D. Marton, 209 Gilkeson Avenue, Pittsburgh, Pa.; Business manager Richard Rimbach, 8550 Babcock Blvd., Pittsburgh 37, Pa.

2. The owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual member, must be given.)

Richard Rimbach, Sr., Pittsburgh, Pa.; Mrs. Richard Rimbach, Pittsburgh, Pa.; Richard Rimbach, Jr., Pgh., Pa. Mrs. M. F. Behar, New York, N. Y.; Milton Aronson, Pgh., Pa., Martha Rimbach, Pgh., Pa., Gretchen Rimbach, Pgh., Pa.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown was: (This information is required from daily, weekly, semiweekly, and triweekly newspapers only).

Richard Rimbach, Publisher

Sworn to and subscribed before me this 1st day of September, 1959.
(SEAL) John T. Roscher,
(My commission expires Feb. 6, 1963)

CIRCLE 76 ON READER-SERVICE CARD

Ten To One

New Fenwal Monitor simultaneously brings 10 remote temperature signals to one central location

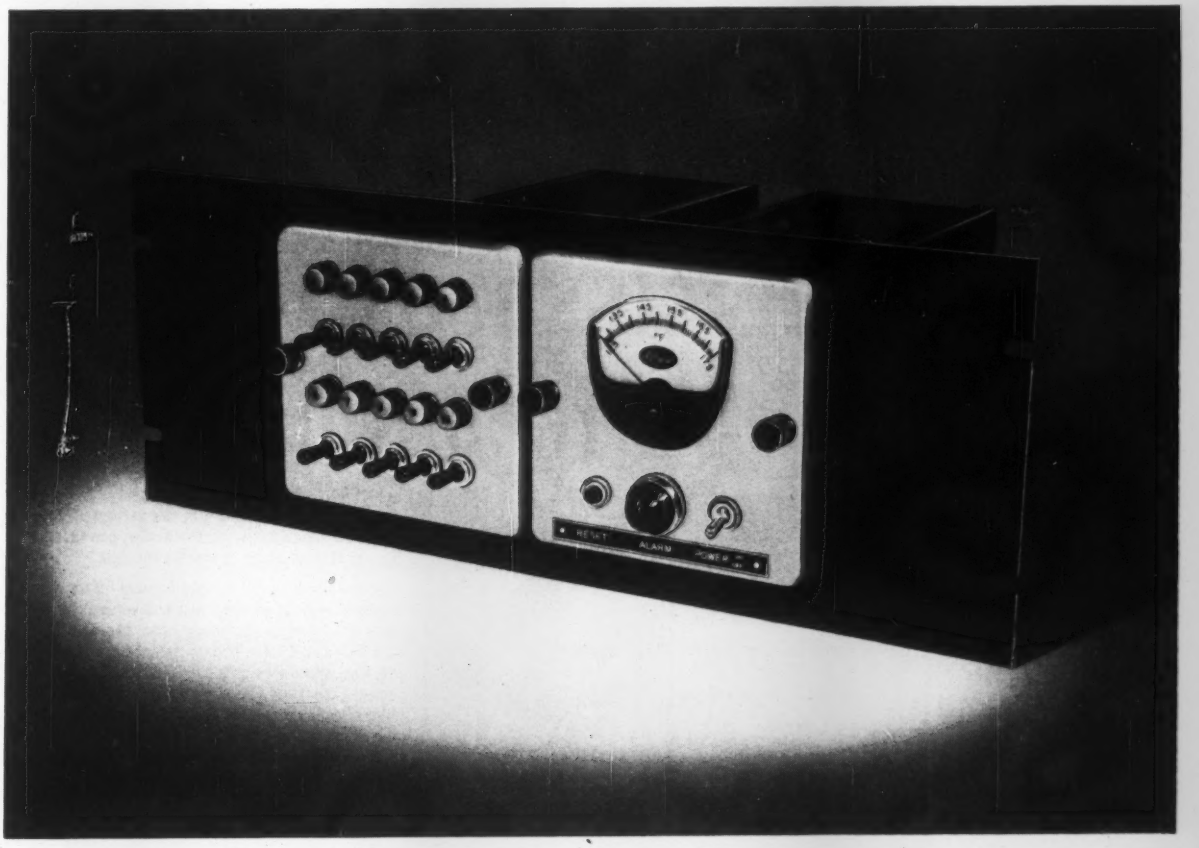
Now there's a monitor that continuously and simultaneously senses all ten of its temperature points. No scanning required . . . no delay in signalling "off" temperatures. *Ten to one it's the positive, fast-acting protection you've needed!*

Monitor's solid-state components are simple, accurate and reliable. Fenwal thermistor sensors install economically with uncompensated electric wiring, have practically limitless life. They change resistance sharply when temperatures change, send strong electrical signals to a rugged, transistorized amplifier. *Wear-free, non-moving parts that combine high performance with low maintenance!*

Fenwal Simultaneous Monitoring Systems are produced by a company with highly integrated design and manufacturing facilities, including its own source of thermistors. And they're repeatedly proving this "better engineering" in all the new commercial jets and many military aircraft. *Small wonder they're dependable on the toughest industrial assignments!*

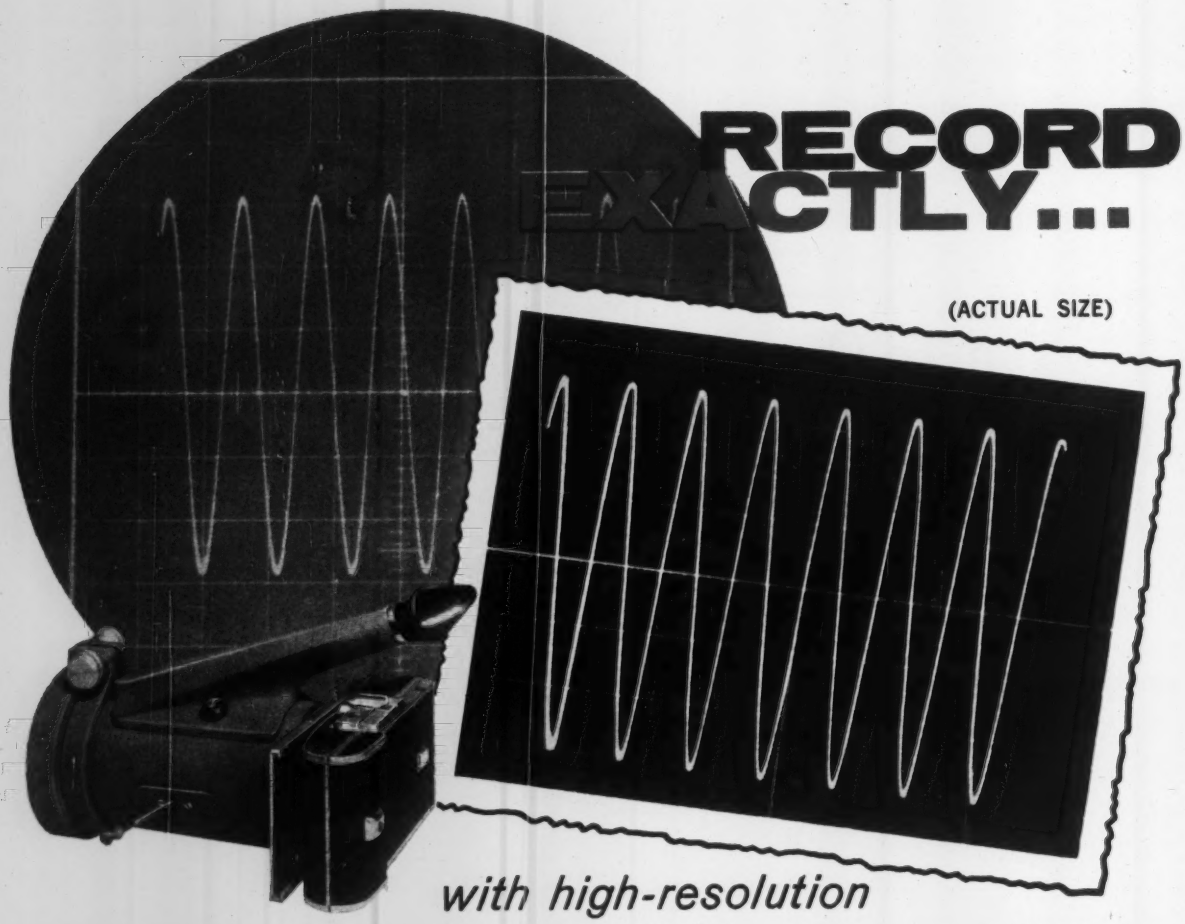
For complete details or complete engineering of your specific temperature monitoring problem, contact a Fenwal Sales Engineer and write for Catalog. Fenwal Incorporated, 3610 Pleasant Street, Ashland, Mass.

Fenwal Continuous 10-point Monitor indicates one or more "off" temperatures by red light or other signal. Operator merely flicks toggle switches to locate trouble. Dial shows each temperature. Temperature Range: 100°F ranges from −25 to 600°F. Voltage rating: 115/230 VAC.



ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

CIRCLE 16 ON READER-SERVICE CARD



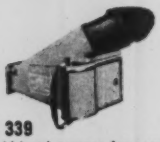
RECORD EXACTLY...

with high-resolution

ACTUAL-SIZE, 60-SECOND PRINTS

DU MONT® 353 record camera

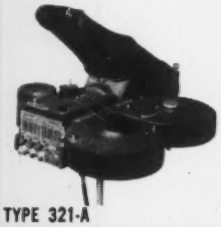
TYPE 299
General-purpose recorder for 5" scopes. Wide variety of backs available.
f/1.9 **$395.00** f/2.8 **$350.00**



TYPE 339
Polaroid-Land camera for recordings from 3-inch scopes. 1:1 object-to-image ratio.
f/2.8 **$150.00**

TYPE 302
Polaroid-Land camera makes 60-second prints on opaque or transparent films.
f/1.9 **$395.00** f/2.8 **$350.00**

TYPE 352
For extremely fast writing rate photography — up to 75 in/usec —on 35 mm film. Automatic operating features enable up to 6 photographs per second.
f/1.5 **$848.00**



TYPE 321-A
Continuous, or single exposures. Perforated or unperforated 35 mm film. Film speeds to 10,800 in/min.
f/1.5 **$1,395.00** f/2.8 **$1,295.00**

In just 60 seconds you can have exact, ready-to-use reproductions of the pattern on the scope screen, exactly the same size, non-reversed, on any standard-type Polaroid Land film*

The new Du Mont 353 Record Camera offers every feature for ease of operation and versatility, such as: 1:1 object-to-image ratio; choice of f/1.9 or f/2.8 lens; sliding detent back for multiple exposures on a single frame; rotatable barrel permitting use of either long or short film dimension; available accessories for use of cut, pack or roll film; easy, fast access to lens and shutter; screen viewing while recording; direct viewing of trace during lens adjustment, to name a few of the many outstanding features.

Price: f/1.9 **$350.00**
f/2.8 **295.00**

*Including Types 46 and 46L positive-transparency negatives.
NOTE: All prices F.O.B., Clifton, N.J., U.S.A.

WRITE FOR COMPLETE CAMERA CATALOG

INSTRUMENT DIVISION, ALLEN B. **DU MONT** LABORATORIES, INC., CLIFTON, N. J., U. S. A.

CIRCLE 17 ON READER-SERVICE CARD

Bristol Dynamaster* Electronic Instruments have proved themselves in thousands of installations. They fully meet today's most exacting standards of accuracy and dependability. They measure almost any variable that can be translated into an electrical quantity (d-c current, d-c voltage, resistance or capacitance). Just a few are: temperature, pH, speed, voltage, smoke density and strain.

Here are some outstanding features that make them ideal for industrial plants, pilot plants, and for research, test, and laboratory use:

1. Continuous standardization—eliminates standardizing mechanism and dry cell—no interruption to control. **But retains precision standard cell for highest accuracy and stability.**

2. Simple design—few moving parts.

3. Easy to use and service—little or no maintenance required.

4. Rugged construction—unaffected by vibration.

MODELS FOR EVERY PURPOSE. Dynamaster Instruments are now available as:

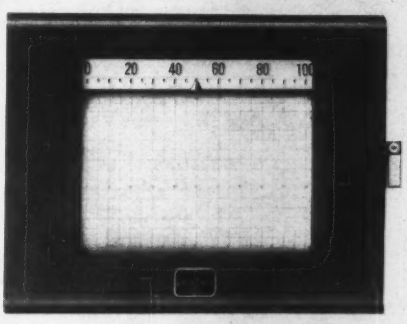
A. Single-pen, two-pen, and multiple-record (up to 24 points) strip-chart instruments.
B. One- and two-pen round-chart recorders.
C. High-speed recorders (0.4 second).
D. X-Y recorders.
E. Extended range recorders.
F. Adjustable span and zero recorders.
G. Miniature 3-inch strip-chart recorders.
H. Electric controllers in both strip- and round-chart models—all types of control action and as time-program control.
I. Pneumatic controllers in both strip- and round-chart models—all types of control action and time-program control.
J. Instruments for electronic measurement—pneumatic transmission of reading by 3-15 psi signal.
K. Round chart program controllers.
L. Telemetering transmitters.
M. Drum-type precision indicators.
N. Multi-bank recorder—will accept up to 200 separate inputs and record them on 12-inch wide strip chart.
O. Relay-rack mounting models—most models available in case that fits standard 19" relay-rack without modification to instrument or rack, without panel-cutting or masking.

Bristol Dynamaster Potentiometer and Bridge Instruments can be equipped with analog-to-digital encoders of various types for digital readout and computer use. For complete details, write for Bulletins P1245A, P1270, P1271, P1242, and P1282. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

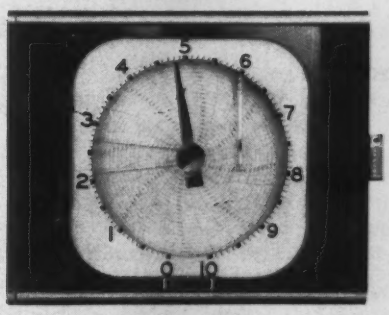
*T.M. Reg. U.S. Pat. Off.

look to Bristol for the complete line of

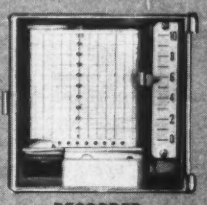
ELECTRONIC POTENTIOMETER and BRIDGE INSTRUMENTS



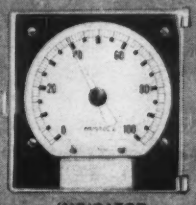
Dynamaster* Electronic Potentiometer or Bridge—records on 11-inch, 120-foot-long strip chart.



Dynamaster* Electronic Potentiometer or Bridge—records on 12-inch round chart, indicates on extra-large scale.



RECORDER



INDICATOR

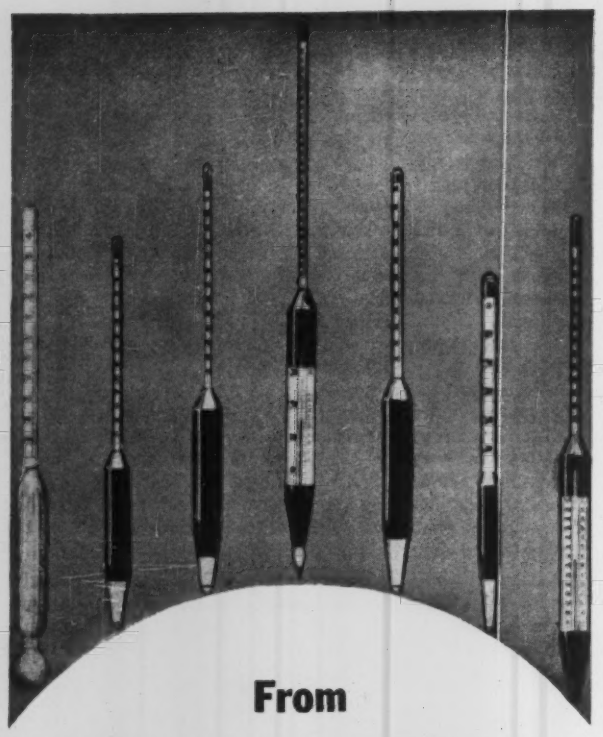
Plug-in Miniature Electronic Dynamaster Potentiometer and Bridge instruments—Only 5" x 5⅛" panel dimensions; ideal for graphic panel instrumentation.

BRISTOL

TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

CIRCLE 18 ON READER-SERVICE CARD



From

Glue to bonded Whiskey

if it's a liquid it has only one

True density—Measure it with

MOELLER HYDROMETERS

Expert design and craftsmanship make Moeller Hydrometers the standard in measuring the density of any liquid. The streamlined tip construction, with special alloy ballast, provides a means of quick, accurate readings. All standard density scales. (Specific Gravity, Brix, Twaddle, Balling, etc.) Available in plain form also in combined form, which has built-in thermometer.

Mail coupon today for special Moeller Hydrometer catalog.

MOELLER INSTRUMENT COMPANY
SINCE 1867
132nd ST. and 89th AVE. • RICHMOND HILL 18, N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me Moeller Catalog No. 800 on Hydrometers.

NAME .....

FIRM .....

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CITY ..... ZONE ..... STATE .....

CIRCLE 19 ON READER-SERVICE CARD

stock report

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

NEW YORK STOCK EXCHANGE

PRICE RANGE FOR 1959 THRU SEPTEMBER 15, 1959

	High	Low	Price As Of 9/15/59
ACF Industries	57	47 5/8	52
Aeroquip Corp.	34 3/4	23 5/8	28 7/8
Allis Chalmers	38 3/4	26 7/8	36
American Chain & Cable	61 3/4	47 3/4	54 1/4 - 55(1)
American Machine & Foundry	100	53 1/2	86 1/4
American Machine & Metals	59 3/4	41	43 1/2
American Optical	53 1/2	38 3/8	46 1/4
American Tel. & Tel.	89	75 1/2	76 1/8
Ampex Corp.	88 1/4	61 1/4	75 3/4
Bausch & Lomb Optical	40 1/2	27	33 1/2
Beckman Instruments	74 3/4	36 1/4	50 1/4
Bell & Howell	74 3/8	53 1/4	56 3/4
Bendix Aviation	89	65 1/4	66
Boeing Airplane	46 1/2	30 1/2	32 1/8
Bullard	24 7/8	16	16 1/2
Bulova Watch	20 5/8	13 1/2	15 1/4
Burroughs	45 3/4	29 5/8	29 3/4
Carborundum	56 3/4	37 3/8	47 1/4
Cincinnati Milling Machine	47 5/8	38 3/4	39 1/4
Clevite	40 3/8	24 3/4	32 7/8
Columbia Broadcasting System	48 3/4	35	40
Consolidated Electrodynamics	45 1/2	33 1/2	34
Consolidated Electronics	53	33 1/2	48
Cornell Dubilier	30 1/2	18	18
Corning Glass	150 1/2	89 3/4	127 1/4
Curtiss Wright	39 1/2	27 1/8	30 3/8
Cutler-Hammer	94 1/4	59 1/2	77
Daystrom	49 3/4	34	37 3/8
Douglas Aircraft	59 3/4	43 1/4	46 1/2
Eastman Kodak	97 3/8	75	89 1/4
Eaton Mfg.	90 3/4	56 1/4	81 1/2
Electric Auto-Lite	55 1/2	36 1/4	47 7/8
Elgin Watch	14	9 3/4	10 1/4
Emerson Electric	69 7/8	48 1/8	56 3/4
Food Machinery & Chemical	55 3/8	40	48 1/2
Gamewell	39 1/4	27	31 3/8
Garrett	50 7/8	38	41 1/8
General Controls	39 1/4	24	28 1/4
General Dynamics	66 1/2	46	46 7/8
General Electric	84 3/4	74 5/8	76 7/8
General Instrument	38 3/8	16 1/2	21 3/4
General Mills	120 1/2	88 1/4	101 1/4
General Precision Equipment	45 1/2	31 1/2	38 3/8
General Railway Signal	39 1/4	32 3/4	34 1/8
General Tel. & Elec.	79	60	68 7/8
General Time	104 1/2	53	74
General Tire & Rubber	83	44 1/8	60 1/4
International Bus. Machines	488	385 1/2	405 1/2
International Tel. & Tel.	45 1/2	28	32 1/8
I-T-E Circuit Breaker	50 1/2	36 5/8	44 1/4
Litton Industries	135 7/8	72 5/8	108 3/4
Lockheed Aircraft	39 3/4	26 1/8	26 1/8
Magnavox	70 3/4	48 1/4	57
Mallory	48 3/4	36 3/8	38 3/4
Minneapolis-Honeywell	150	111 1/2	125
Minnesota Mining & Mfg.	151 1/2	111 1/2	134
Motorola	130	57 1/2	101 1/2
National Acme	63 1/2	50 1/8	50 1/8
National Cash Register	80	57 1/4	58 1/4
Neptune Meter	39 5/8	31	31 1/8
North American Aviation	52 5/8	35 5/8	37 3/8
Northrop Aircraft	44 3/4	27 3/8	27 7/8
Otis Elevator	83	61 1/2	75 3/4
Philco Corp.	36 3/4	21	23 1/2
Radio Corp. of America	71	43 1/8	57 1/2
Raytheon Mfg.	73 7/8	43 1/2	46 5/8
Reliance Electric	63 1/2	42 5/8	58 1/2
Rheem Mfg.	25 3/4	18	20 1/4
Robertshaw Fulton	53 7/8	31 5/8	43 1/4
Royal McBee	24 3/8	16	16 7/8
Sangamo Electric	51 1/2	35	39 3/8
Siegler Corp.	45 1/8	24 1/2	24 5/8
Sperry Rand	28 1/4	21 1/4	23 3/8
Square D	37 1/4	26 7/8	32 1/2
Standard Coil Products	23 3/4	14 3/8	15
Starrett (L.S.)	23 7/8	20	20 3/4
Stewart-Warner	62	42 1/2	53 1/2
Telautograph	13 3/8	9	11 1/2
Texas Instruments	159 1/2	61 1/4	127 1/4
Thompson-Ramo-Wooldridge	70 1/4	52	53 3/4
Tung-Sol Electric	54 1/4	34 1/8	36 1/2
Underwood Corp.	30 7/8	19 1/4	19 3/4
Union Carbide Corp.	150 1/2	120 1/2	134 1/2
United Shoe Machinery	58 3/8	45 5/8	55 1/4
Varian Associates	32 1/2	29 1/2	29 3/4
Wallace & Tiernan	52 7/8	36 1/4	42
Western Union	43 7/8	29 3/4	37 7/8
Westinghouse Air Brake	38 1/2	28 7/8	29 3/8
Westinghouse Electric	98 3/8	70 1/2	88
Worthington Corp.	84 1/2	67 1/2	69

(1) Not traded — Bid and Asked.

AMERICAN STOCK EXCHANGE

PRICE RANGE 1959 THRU SEPTEMBER 15, 1959

	High	Low	Price As Of 9/15/59
American Meter	47 1/4	38	44 1/4
Aro Equipment	29 3/4	21	21 1/4 - 22(1)
Barry Controls "B"	26	13 3/4	17 1/2
Belock Instruments	22 7/8	10 3/8	15 1/4
Benrus Watch	9	5 7/8	6 3/4
Breeze Corp.	9 3/8	6 1/4	6 5/8
Clark Controller	30 3/8	19 5/8	22 1/4
Clarostat Mfg.	10 1/4	4	6 7/8

Continued on page 1474

ANOTHER NEW LESLIE PRODUCT

ADJUSTABLE PROPORTIONAL BAND Floatless LIQUID LEVEL CONTROL

...with adjustable level ranges up to 0-200"

Here is a new differential pressure-type liquid level control pilot that combines the wide adjustable level ranges in the table shown below with a 2-20" or 7-25" adjustable proportional band.

ADJUSTABLE LEVEL RANGE — INCHES	ADJUSTABLE PROPORTIONAL BAND (INCHES, H_2O)	CONTROL PILOT TYPE
0-40 or 0-87	2-20	LAP
0-30 or 0-91	2-20	LABP
0-200	7-25	LAUP

Maximum Static Pressure — 300 psi

One Knob — Easy Adjustment

A single knob adjustment quickly sets the proportional band where you want it, even while the system is in operation. The liquid level is maintained constantly within that band until you re-set the control pilot for new conditions.

Applications

Leslie-Level-Matic Control Pilots are used in either open or pressurized vessels to control the level of virtually any liquid including water, gasoline, oil and chemical solutions. The new control pilot is particularly useful to maintain constant levels where there are high flow rates through vessels with small cross sectional areas.

Float Cages Eliminated

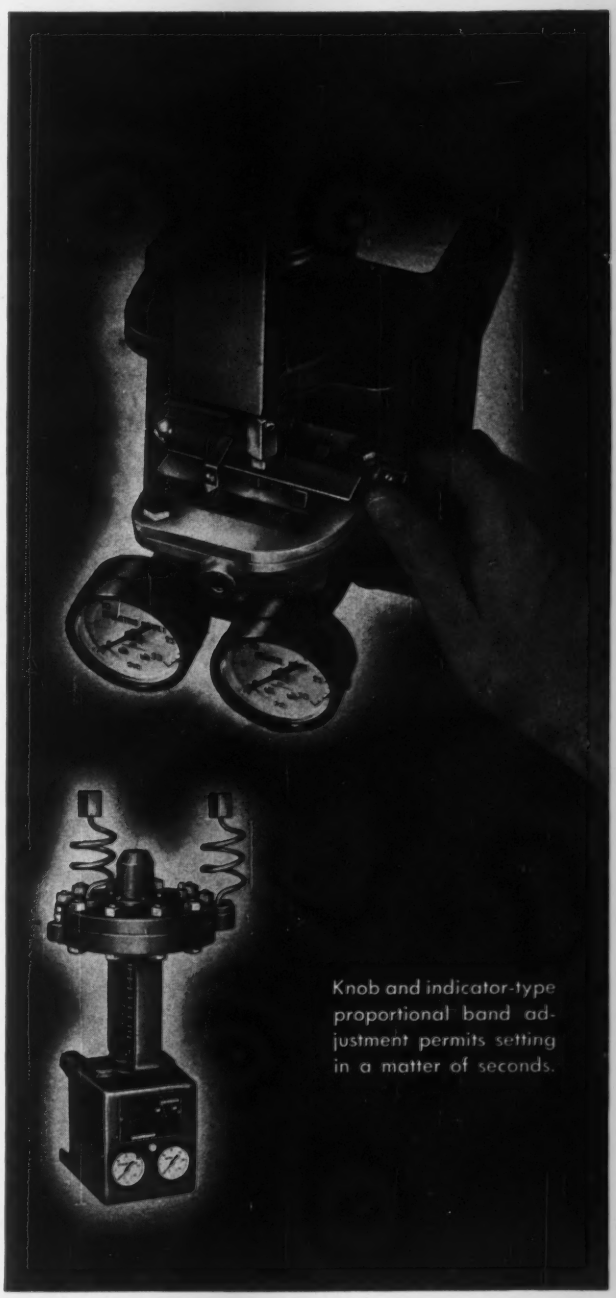
There are no floats or cages needed for Leslie-Level-Matic Control Pilots, and no torque tube seals, stuffing boxes, or thermohydraulic systems. All of the primary control elements are in one place and may be installed with a fraction of the effort and cost required for displacement-type controllers.

Vibration-Proof, Dependable

All of the dependability factors for which Leslie products are so well-known are incorporated in this new control pilot, as well. Rugged, accurate, stable — it is unaffected by normal vibration or turbulence.

More Information

Send for Engineering Data Sheet describing this new Control Pilot and outlining its principle of operation.



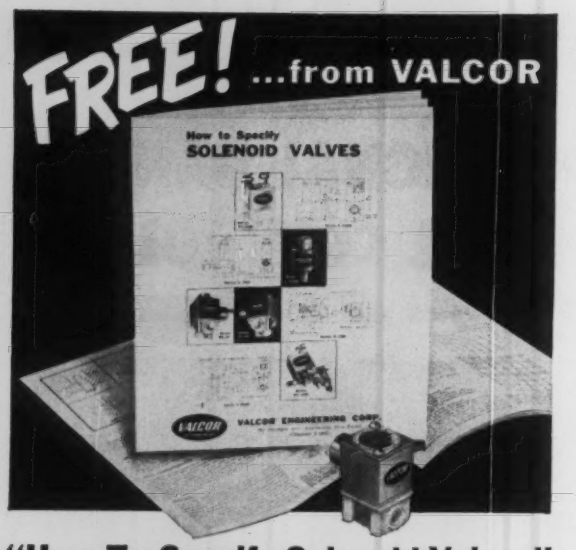
Knob and indicator-type proportional band adjustment permits setting in a matter of seconds.

LESLIE **REGULATORS and CONTROLLERS**

874

LESLIE CO., 499E Grant Avenue, Lyndhurst, New Jersey

CIRCLE 20 ON READER-SERVICE CARD



"How To Specify Solenoid Valves"

A complete, illustrated guide for calculating flow and pressure drop characteristics...how to determine the most suitable valve configuration...what type of sealing principle is best for you...how to eliminate costly over-specifying. Invaluable to engineering and purchasing personnel.

WRITE TODAY FOR YOUR FREE COPY.

VALCOR SOLENOID VALVES

VALCOR ENGINEERING CORP.

5366 CARNEGIE AVE., KENILWORTH, N. J.
CHESTNUT 5-1665

CIRCLE 21 ON READER-SERVICE CARD

American Stock Exchange: *Continued from page 1472*

Clary Corp.	10 7/8	5 3/4	7 1/8
DuMont Laboratories	9 7/8	6	6 3/4
Dynamics Corp. of America	12 3/4	4 5/8	8 5/8
El-Tronics	2 1/4	1	1 1/2
Electronics Corp. of America	16 7/8	7 7/8	8 1/4
Fairchild Camera & Instrument	205	50 3/4	147
General Transistor	45 3/8	29	34
Globe-Union	27 3/4	20 1/4	22 7/8
Hazeltine Corp.	33	24 1/2	25 1/2
International Resistance	22 3/4	7	15 5/8
Lear Inc.	19 1/4	9 1/8	13 1/4
National Research	39 1/2	15 3/8	20 3/8
New Haven Clock	5 3/8	1 1/2	2 3/4
Nuclear Corp. of America	4 1/4	1 3/4	2
Philips Electronics, Inc.	50 1/4	23 1/2	37 1/8
Pneumatic Scale	67	32	43
Servo Corp. of America	43 1/2	14 5/8	23 1/2
Servomechanisms	18 1/4	9	9 1/4
Statham Instruments Inc.	43	23	25 1/2
Victoreen Instrument Co.	19 7/8	6 7/8	12 1/2
Waltham Prec. Instrument Co.	4 3/8	1 1/8	2 5/8

(1) Not traded — Bid and Asked.

OVER THE COUNTER

	Quotation as of 9/15/59	
	Bid	Asked
Aerovox Corp.	9 3/4	11
Aircraft Radio Corp.	55	--
Argus Corp.	34 1/2	35 1/2
Black Sivalls & Bryson Inc.	22 3/4	23 5/8
Eitel McCullough	20 3/4	21 1/2
Electro Instruments	32	34
Electronics Associates	33	35
Erie Resistor Corp.	8	8 3/4
Fisher Governor Co.	16 1/2	17 3/4
Foxboro Company	66 1/2	69 1/2
Giannini Controls	22 1/2	24 1/4
Hagan Chemicals & Controls	32 1/4	33 1/2
Industro Transistor	6 1/4	6 7/8
Liquidometer Corp.	7 1/2	8 3/4
W. L. Maxson	11	11 3/4
Penn Controls	22 1/4	23 1/4
Speer Carbon, Inc.	19	20 1/2
Sprague Electric	48	51
Taylor Instruments	35 1/4	36
Telecomputing Corp.	9 3/8	10 7/8
Topp Industries	10	11 1/2
Vitro Corp. of America	12	13 1/8

IT'S THE NEW MARK II FROM WESTON:

an advanced new design for the WORLD'S FINEST PORTABLE ANALYZER

Here's an all-new version of the famous WESTON MODEL 980 Volt-Ohm-Milliammeter . . . engineered to offer you

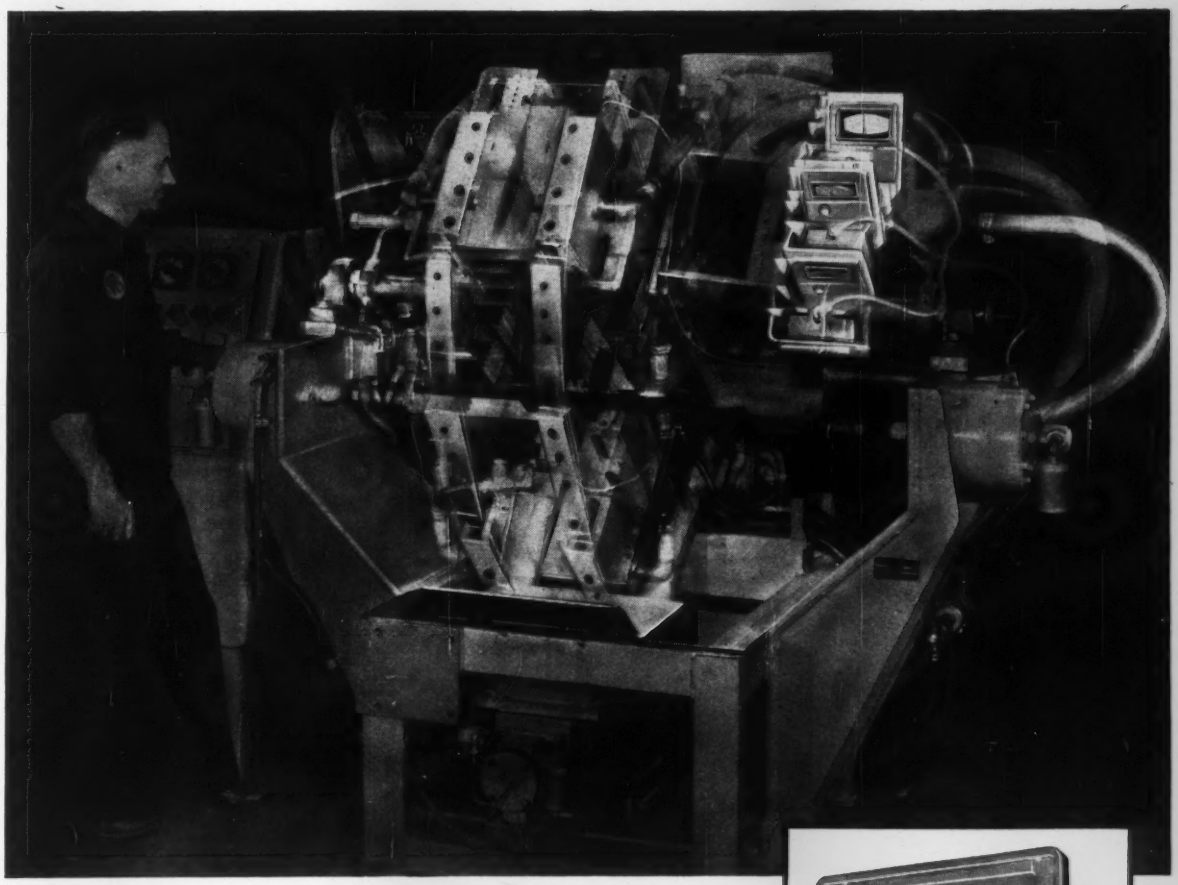
- **INCREASED RANGE.** High-voltage range has been extended to 4000 volts.
- **INCREASED SENSITIVITY.** D-C sensitivity of 20,000 ohms/volt; accuracy within 2% of full scale.
- **IMPROVED SHIELDING.** Cormag® mechanism assures positive magnetic shielding; housing shields against electrostatic interference.
- **GREATER RUGGEDNESS.** Spring-backed jewel movement resists shock, vibration; case is impact-resistant. Ohm-ranges are fuse-protected.
- **SIMPLIFIED CONTROL.** Single dial control for range and function switching.
- **NEW COMPACTNESS.** Size and weight are reduced for maximum convenience and portability.

Order from your local Weston distributor. For information, write to Daystrom-Weston, Sales Division, Newark 12, N. J. *In Canada: Daystrom, Ltd., 840 Caledonia Rd., Toronto 19, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.*

WESTON *Instruments*

WORLD LEADER IN MEASUREMENT AND CONTROL

CIRCLE 22 ON READER-SERVICE CARD



A Partlow Model MFS indicating controller is shown in action in this "multiple exposure" shot of a Holo-Core Automatic Molding Machine manufactured by Spo, Inc., Cleveland, Ohio.

The Temperature Control Built to
SHRUG OFF SHOCK
2438 Times a Day

Every working day, the Partlow Temperature Control in this photo takes between 2400 and 2500 solid "roundhouse punches" from the shell-molding machine to which it is attached.

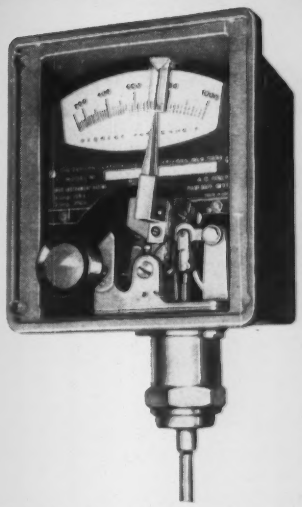
But despite jarring shock and vibration, and a constant barrage of foundry dust, the Partlow goes right on delivering precision control—without letup or breakdown.

Actually, only a control as simple and rock-solid as the Partlow could withstand this kind of punishment! Because only the Partlow contains no hairsprings, or delicate gadgets.

All Partlow thermal elements of the same range are interchangeable *on the job*, too. There's no time lost waiting for your control to come back from the factory. And you get this extra margin of dependability *without loss of accuracy*. Partlow controls are precise to within 1% of scale in any one of 10 ranges from -30° to 1100° F.

If you use or manufacture equipment within this temperature range, there's a Partlow to fit your application exactly . . . and save you money, too. Available in Pneumatic, Electric or Self-Contained Gas types, in recording, indicating or non-indicating models! To field test any Partlow control . . . or to obtain full details write, The Partlow Corporation, New Hartford, N. Y. Dept. IA109.

Export Ad, Auriema, Inc., 85 Broad St. New York 4, N. Y.



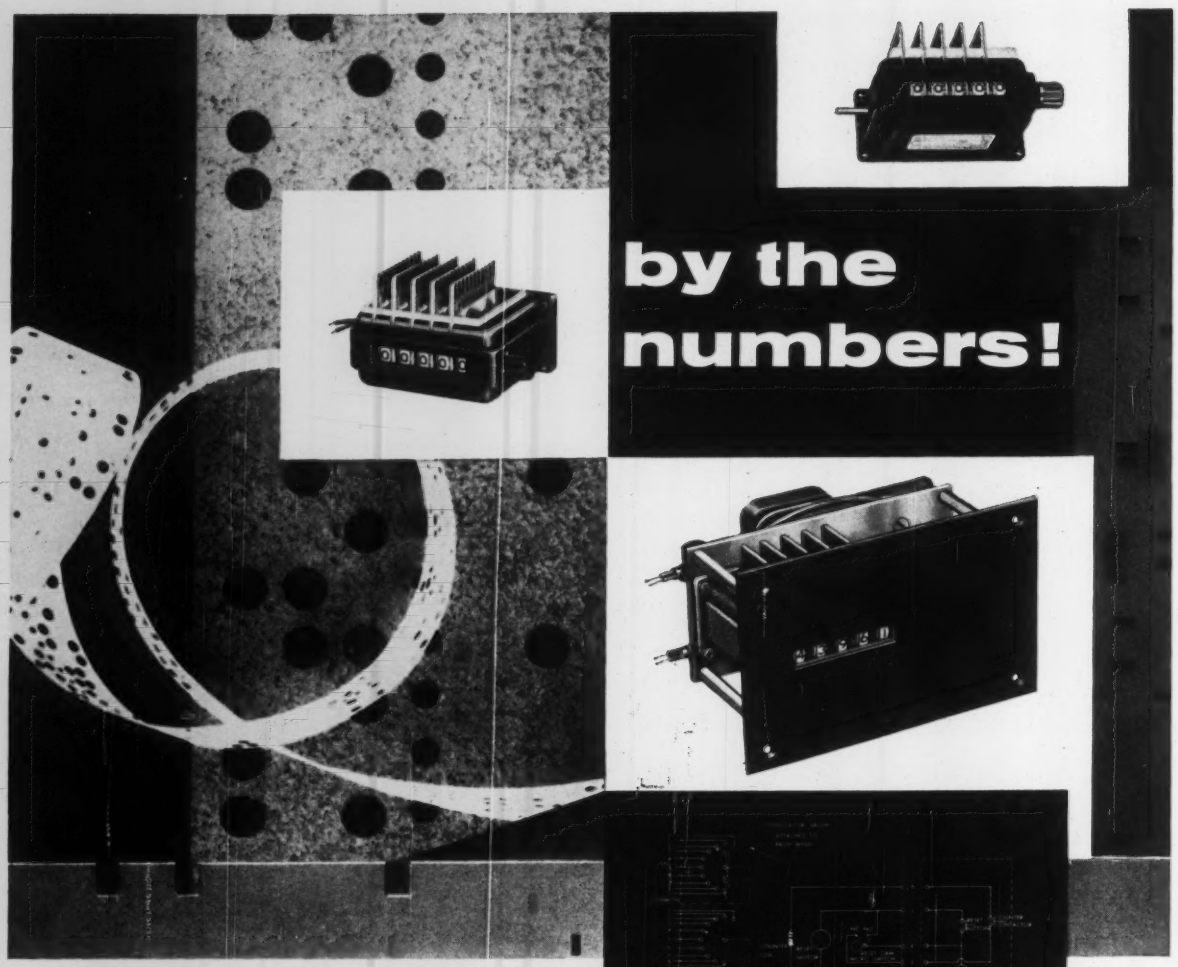
A complete absence of gadgets and superfluous parts, as seen in this open view of the new MFS indicating control, explains the Partlow's unique ability to function accurately even under the most severe operating conditions.

You can pay more but you can't buy better than

PARTLOW

TEMPERATURE CONTROLS

CIRCLE 23 ON READER-SERVICE CARD



by the numbers!

Remote Readout Counters Simplify Automatic Data Processing

How these counters work: Data Readout Counters are actuated mechanically by rotation of a shaft or electrically by making and breaking a circuit. Each wheel has a printed circuit, with a contact for each digit. Remote Data Readout Counters are available with manual or electrical reset, and for base or panel mounting. Standard Models are available from stock.

Now . . . Veeder-Root Remote Data Readout Counters can provide a low-cost method of collecting and feeding important information . . . by transmitting counter readings electrically.

Counter readings can be fed directly onto a punched card or tape, and into adding machines or any other data handling devices. The counter can actuate alarms or control machines to predetermined settings. And they can be arranged for automatic reset and recycling. External circuits can be designed to transmit totals in binary code, international code or in digital form.

Remote Data Readout gives you many unusual opportunities to put *Count*rol to work. Automatic processing of machine production, and shaft rotation, remote digital readout, centralized control, simplified automation, and printing and computing applications are just some of the intriguing possibilities available with remote data readout.

Send for Veeder-Root Technical Information . . . Complete specifications on Remote Data Readout Counters will be sent at once; and application assistance is available if desired.

Veeder-Root inc.
HARTFORD 2, CONNECTICUT
"The Name that Counts"

Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
New York • Los Angeles • San Francisco • Seattle • St. Louis • Montreal
Offices and Agents in Principal Cities

VR9-57

CIRCLE 24 ON READER-SERVICE CARD

Case Type No. 1279.

Case Type No. 1379 is Alumalife, while similar case Type No. 1079 is Cast Iron.

Case Type No. 1377.

In such cases DURAGAUGES® naturally serve longer

You have a choice of three case materials—Alumalife®, a special aluminum alloy, Cast Iron, rugged and durable, Phenol, tough and rigid plastic—plus the unique "Maxisafe" design when you specify Ashcroft Duragauges.

All three case materials use a chrome plated, die-cast retaining ring to keep out harmful fumes and dirt. Case construction simplifies servicing—the entire system can be easily removed for recalibration or repair.

The "Maxisafe" case provides absolute protection to the viewer, easy and quick access to the tube and movement assembly. An integrally cast solid wall separates the dial from the tube and movement. A safety cover plate on the back is held in position by a knurled knob.

Regardless of your gauge case requirements, there's an Ashcroft Duraguage to do the job. Contact your local Ashcroft Gauge Distributor for complete facts.

Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi.

CASE MATERIALS, TYPE NUMBERS, MOUNTING AND SIZES

CASE	TYPE NO.	BACK FLANGE	MOUNTING		CONNECTION		DIAL SIZE
			WALL	FLUSH	LOWER	BACK	
Black Alumalife	1379	Yes	Yes	Yes	Yes	Yes	4½", 6"
Black Cast Iron	1079	Yes	Yes	Yes	Yes	Yes	4½", 6", 8½" 10", 12"
Black Phenol, Turret Design	1279	No	Yes	Yes*	Yes	Yes	4½", 6", 8½"
Black Alumalife**	1377	No	No	Yes	No	Yes	4½", 6", 8½" 10", 12"

**May be flush mounted by using Flush Mounting Ring, Catalog No. 1278.*
***The 10" and 12" dial sizes are made in cast iron only.*

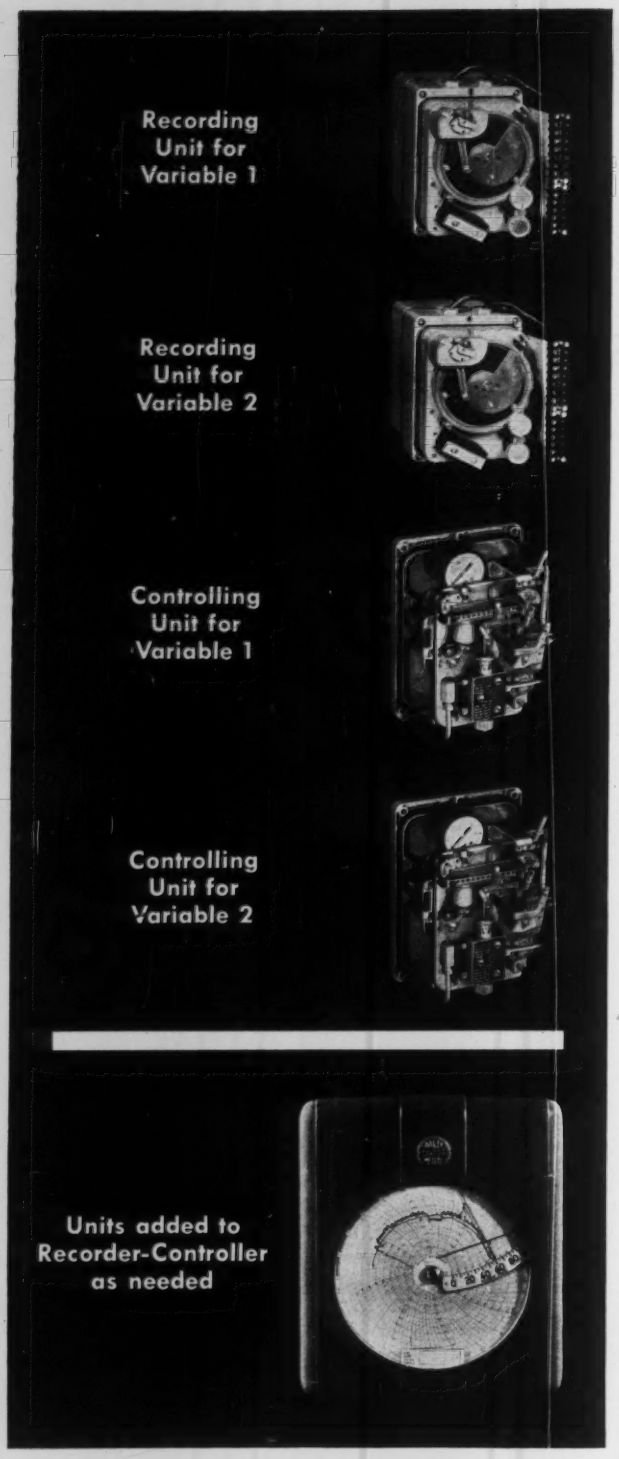
ASHCROFT PRESSURE GAUGES

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 25 ON READER-SERVICE CARD


Recording Unit for Variable 1
Recording Unit for Variable 2
Controlling Unit for Variable 1
Controlling Unit for Variable 2
Units added to Recorder-Controller as needed

Bailey Recorder is key to "step-by-step" automation

When you are pioneering a new process and don't know all the answers, complete automation is seldom practical. The first step is to identify your variables and measure them. Nothing does this job better than a Bailey Recorder. One instrument can record any four variables that can be converted to electric *or* pneumatic signals.

Once you get a better understanding of the variables in your process, you will want to add controls and feed back your measurements. Here's where the versatility of the Bailey Recorder comes into play. For the same Bailey instrument you use to record variables is designed to accommodate plug-in control units.

When you use a Bailey Recorder, you can build your instrumentation along with your process. At the start, you use only the plug-in units for recording. Then you add plug-in controls as you see the need for them.

For the complete story of how you can use a Bailey Recorder for step-by-step automation, see your Bailey Engineer.

G-42-1

Instruments and controls for power and process

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

CIRCLE 26 ON READER-SERVICE CARD

events

October 25-27
Fluid Controls Institute Fall Meeting, Seaview Country Club, Absecon, N. J. For information write R. McCormick, Automatic Switch Co., Florham Park, N. J.

October 26-28
First International Symposium on Gas Lubricated Bearings, Shoreham Hotel, Washington, D.C. For information write Albert Hollingsworth, Franklin Institute Laboratories, Phila. 3, Penna.

October 28-29
Michigan Industrial Electronics Exposition, Detroit Artillery Armory, Detroit, Mich. For information write W. G. Henschen, 830 W. Vernor Highway, Detroit 1, Mich.

October 28-29
6th Annual Computer Applications Symposium, Morrison Hotel, Chicago, Ill., Armour Research Foundation of the Univ. of Ill., Write M. J. Jans, Conf. Secy., Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

October 29-30
5th Annual Electron Devices Meeting, Shoreham Hotel, Washington, D. C., PGED-IRE, Write J. J. Lanigan, Pub. Chrman, Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.

November 3-5
1959 Mid American Electronics Conference (MAECON) Midwest Research Institute, Kansas City, Mo., Sponsored by KC Section, IRE. Write Paul C. Constant, Jr., Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Mo.

November 4-6
Sectional Meeting of Society for Applied Spectroscopy & Instrument Exhibition. Hotel New Yorker, N.Y.C. For information write M. F. Wilson, Air Reduction Corp. Research Lab., Murray Hill, N. J.

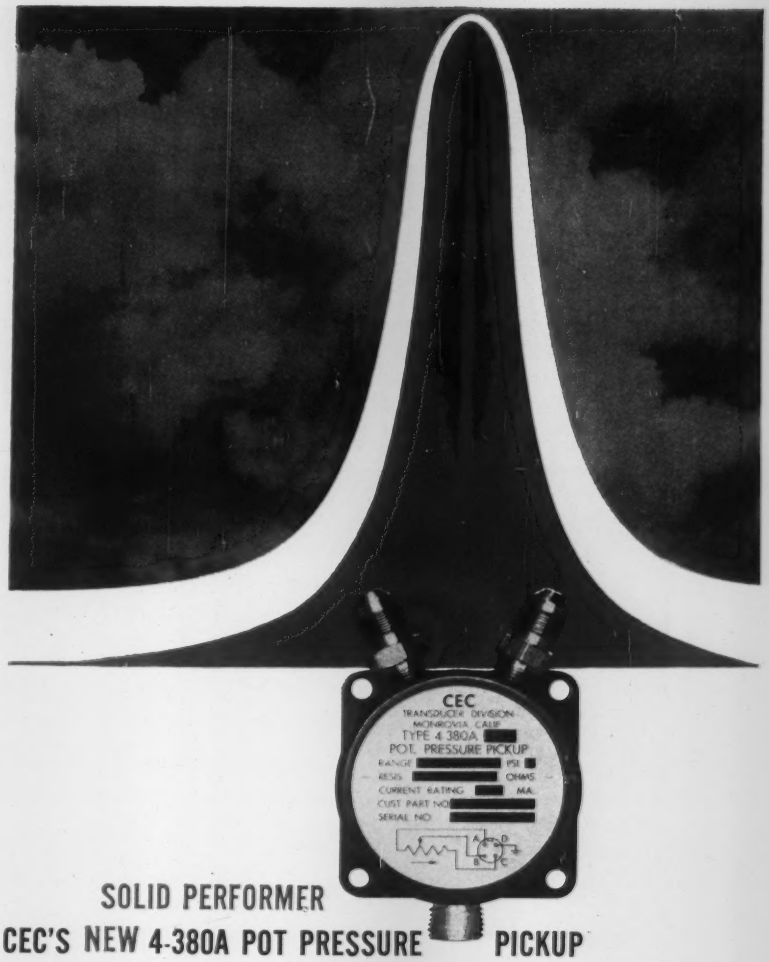
November 4-6
Eastern Analytical Symposium and Instrument Exhibit, New Yorker Hotel, N.Y.C. For information write Paul Lublin, Sylvania Research Laboratories, Bayside, N.Y.

November 4-6
National Automatic Control Conference, IRE-PGAC, Sheraton-Dallas Hotel, Dallas, Texas. Write Prof. F. W. Tatum, E. E. Dept., Southern Methodist University, Dallas, Texas.

November 5-6
Control Systems Components Conference, held jointly with National Automatic Controls Conference, Sheraton Hotel, Dallas, Texas. For information write Denny Pidhayny, Ramo-Wooldridge, P.O. Box 90534 Airport Station, Los Angeles 45, Calif.

November 5-6
Eighth Annual Instrumentation Conference, on campus of Louisiana

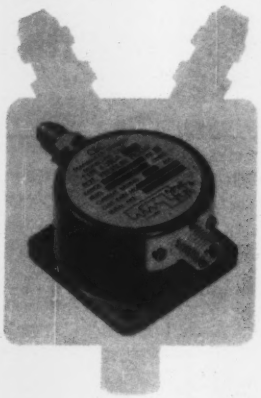
Continued on page 1482



SOLID PERFORMER

CEC'S NEW 4-380A POT PRESSURE PICKUP

Now with a redesigned flexure support system, the 4-380A sets a new standard of performance for low-pressure potentiometer pressure transducers. The 4-380A is unequalled for resistance to shock and vibration. Most pressure ranges are capable of continuous exposure to 25 g vibrations up to 2 KC for periods up to several hours with negligible change in calibration.



Pressure ranges are available from ±1 psi to 100 psi. Absolute, gage, and differential models are offered. Operating over the temperature range from −65° F to +200° F, most pressure ranges exhibit temperature effect of less than one percent. The unique construction of the 4-380A keeps the measured fluid external to the mechanical and electrical system. In absolute models, the internal mechanisms are enclosed within the evacuated chamber. For detailed specifications, call your nearest CEC sales and service office, or write for Bulletin CEC 1604-X17.

Transducer Division CEC

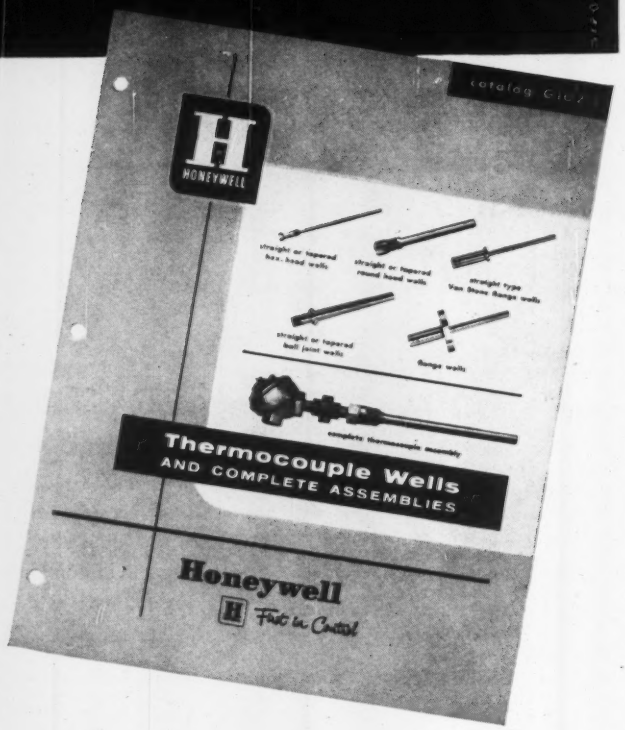
CONSOLIDATED ELECTRODYNAMICS / 360 sierra madre villa, pasadena, california

CIRCLE 27 ON READER-SERVICE CARD

NEW HONEYWELL CATALOG

helps you choose the right

THERMOCOUPLE WELLS



Here's valuable help in the often-perplexing job of picking the right thermocouple wells and assemblies for particular applications.

This new Honeywell catalog brings you a wealth of useful data . . . provides all the information you need to make the right selection every time. Included in the catalog are:

- **Well designs and dimensions**
- **Pressure and temperature ratings**
- **Corrosion data**
- **Thermocouple assembly data**
- **Ordering and pricing information**

Honeywell

First in Control

FILL OUT AND MAIL THE COUPON FOR YOUR COPY—NO OBLIGATION

MINNEAPOLIS-HONEYWELL
Wayne and Windrim Avenues
Philadelphia 44, Pa.

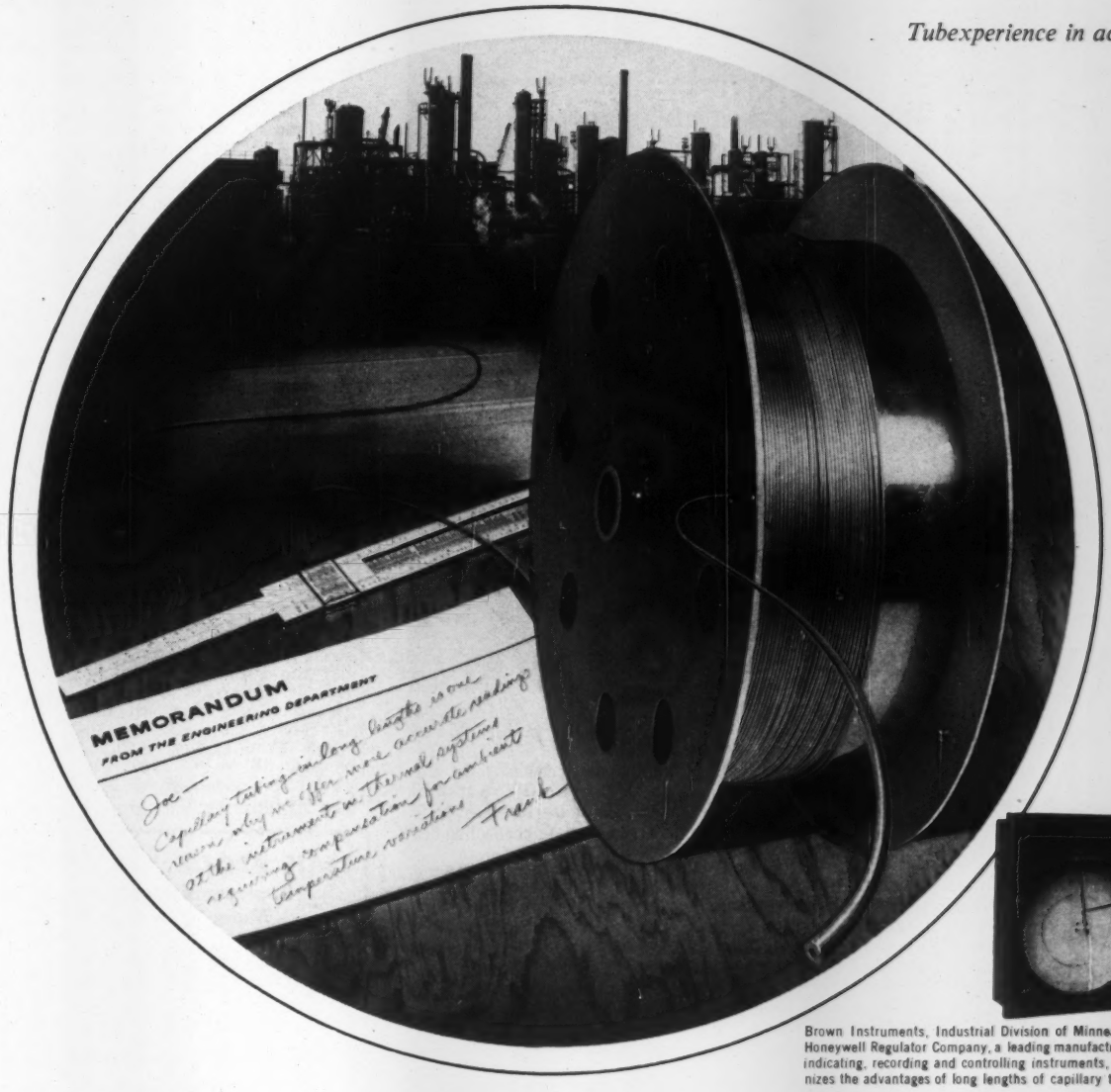
Please send me a copy of the new Thermocouple Wells Catalog G102-1.

Name_____ Title_____

Company_____

Address_____ City_____ Zone_____ State_____

CIRCLE 28 ON READER-SERVICE CARD


MEMORANDUM
FROM THE ENGINEERING DEPARTMENT
Joe—
Capillary tubing in long lengths is one reason why we offer more accurate reading of the instrument in thermal systems requiring compensation for ambient temperature variations
Frank

Brown Instruments, Industrial Division of Minneapolis-Honeywell Regulator Company, a leading manufacturer of indicating, recording and controlling instruments, recognizes the advantages of long lengths of capillary tubing.

Up to 3000 ft. of capillary tubing in 1 piece

Seldom does an instrument installation require 3000 ft. of capillary tubing in one piece—the quantity is normally much less. But the advantages of long lengths are numerous. A simple long length of capillary tubing has greater ID uniformity than a series of short lengths separately produced. This permits more accurate transmission of data between instruments controlling a process. Instrument manufacturers find that long lengths reduce scrap. They also lessen the number of setups required and the costs of inserting the capillary tubing in flexible metallic protective sheathing.

Superior has spent years in the development of manufacturing processes and quality control procedures for the production of close tolerance tubing. ODs range up to 3/16 in., IDs from .004 through .040 in. Analyses include Types 304, 316, 321, 347 and 446 stainless; also Monel, Inconel, nickel and carbon steel alloys. Data Memorandum No. 11 gives complete details—let us send you a copy. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

Monel and Inconel are registered trademarks of International Nickel Co.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to 5/8 in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

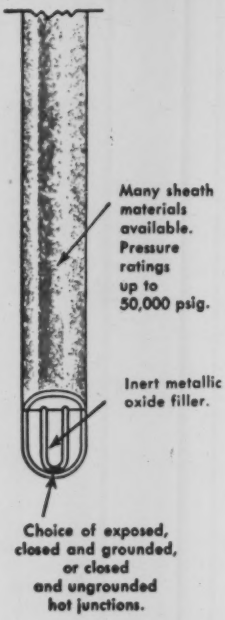
CIRCLE 29 ON READER-SERVICE CARD

FOR POINT-OF-READING ACCURACY...

TRINITY

Trinox

metal-sheathed thermocouples designed and built for maximum accuracy, response speed, and dependability...


Many sheath materials available. Pressure ratings up to 50,000 psig.
Inert metallic oxide filler.
Choice of exposed, closed and grounded, or closed and ungrounded hot junctions.

Trinox units offer the user a single unit combining the protection of a thermowell and the accuracy of a fine thermocouple. The thermocouple is encased in an inert metallic oxide within a metal sheath with the proper process connection and junction.

Inherent small size of Trinox lends itself to miniaturization. Extremely fast response permits more accurate readings and control in critical systems. Trinox units may be formed into practically any configuration to meet requirements, and are available in .040", 1/16", 1/8", 3/16", 1/4", 5/16" diameters. Trinox is also available from stock in random lengths for customer fabrication.

FOR MULTI-POINT ASSEMBLIES

Single process connection can accommodate a number of Trinox units with hot junctions at various points as required.

WRITE FOR COMPLETE DETAILS...

On Trinity Thermowells for all applications, Thermocouples and Trinox Thermocouples.

TRINITY THERMOWELLS • THERMOCOUPLES

Dynamic Dryers, Heat-Les and Heat-reactivated.

TRINITY EQUIPMENT CORPORATION, CORTLAND, NEW YORK

CIRCLE 30 ON READER-SERVICE CARD

EVENTS—CONTINUED

Polytechnic Institute. For information write Stewart Baggarly, Louisiana Polytechnic Institute, Ruston, Louisiana.

November 9-11

Fourth IRE Instrumentation Conference, Atlanta Biltmore Hotel, Atlanta, Ga. For information write William Bradley, Scientific Atlanta, Inc., 2162 Piedmont Rd., N.E., Atlanta 9, Ga.

November 10-15

International Exhibition of Laboratory, Measurement and Automation Techniques in Chemistry, Swiss Fair Buildings, Basle, Switzerland. For information write Emil M. Bammater, Swiss Industries Fair, Basle 21, Switzerland.

November 16-19

5th Conference on Magnetism and Magnetic Materials, Sheraton-Cadillac Hotel, Detroit, Mich., Sponsored by Univ. of Mich., IRE, Am. Phys. Soc., ONR, AIEE and Met. Soc of AIME. Write D. M. Grimes, Dept. of E. E., Univ. of Mich., Ann Arbor, Mich.

EXPOSITION POSTPONED

PITTSBURGH—Management for the Fifth International Automation Congress and Exposition has announced postponement of the show scheduled for the New York Trade Show Building, November 16 to 20, 1959. The show will be rescheduled for 1961.

LEAK PROOF VALVES...

Replaceable Soft Seat Metering or Flow

HI-VACUUM TO 6,000 PSI

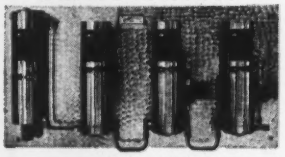
PNEUMATIC HYDRAULIC

ANGLE—GLOBE—THREE PORT—MANIFOLD

ROBBINS Aviation, Inc.

2350 E. 38th St.—Los Angeles 58, Calif.

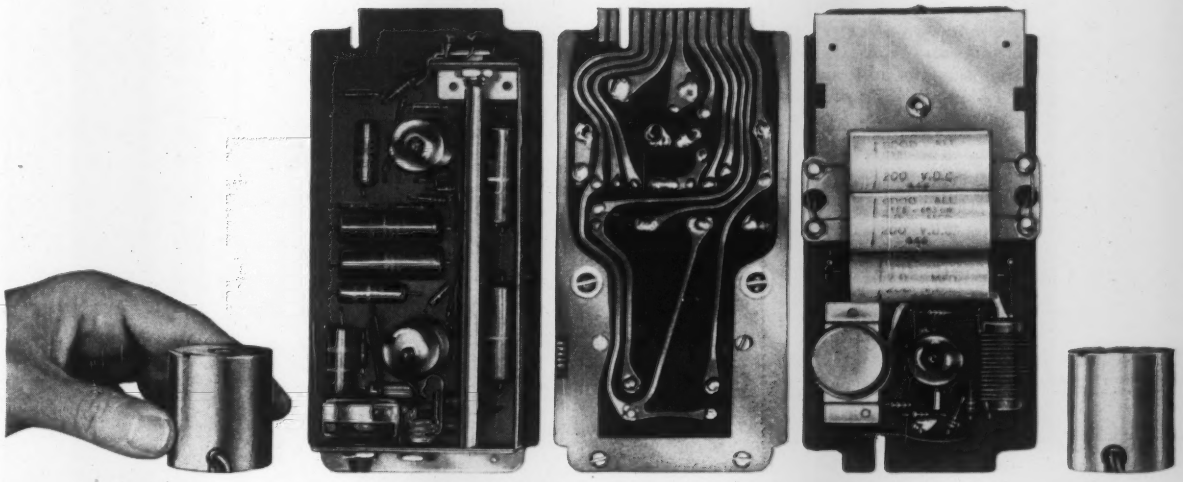
DEHYDRATION



Remove moisture & oil vapor from gases with working pressures up to 12,000 PSI; dew points -100°F.

CIRCLE 73 ON READER-SERVICE CARD

CONTROL SYSTEMS RELIABILITY?



SWARTWOUT SIMPLICITY PUTS IT ON THE LINE

ONLY FIVE BASIC ELEMENTS IN THE WHOLE AUTRONIC® LOOP!

Here you have it: all the electronic components of a typical, complete AutroniC control loop. On the left, a differential transformer to provide the process signal; on the right, another for the set-point signal. In the middle, the three neat printed-circuit cards that handle all basic controller functions. The AutroniC System is essentially that simple. Deliberately so.

It was Swartwout, you know, who started this whole business of electronic process control. And Swartwout it is, who now leads the field with the most extensive line of equipment . . . the broadest breadth of experience . . . and the proudest record of successful installations.

Experience of our customers has confirmed our belief that simplicity is the best single determinant of reliability. So, no extra gimcracks or gadgets; the AutroniC System is as lean as an Olympic miler. Premium components keep it in top condition . . . even under year-in and year-out use.

Before you put down your dollars for an electronic control system, give Swartwout AutroniC Control a good looking over. You'll like what you see. Try Bulletin A-913 for a starter.

SWARTWOUT

. . . world leader in electronic process instrumentation

THE SWARTWOUT COMPANY
18511 EUCLID AVENUE
CLEVELAND 12, OHIO

S.A. 2082

CIRCLE 32 ON READER-SERVICE CARD

← CIRCLE 31 ON READER-SERVICE CARD

The only chart drive that

During Hurricane "Flossy" all oil production on the Gulf Coast closed down because it was impossible to get out and wind the intermitters. A prototype of the newly announced Rockwell Gas Drive ran constantly through this emergency on a Pure Oil well, off the coast of Louisiana. A number of these drives have also been in successful service in the production regions of Wyoming and Canada operating through two cold weather seasons at temperatures down to −40° below zero. All in all, the new Rockwell Gas Drive has been rigorously field tested for over 2½ years.

Rockwell Gas Drive powers this typical intermitter

FEATURES

- **Powered by gas or air—no winding**
- **Built right into a standard Rockwell chart drive case**
- **Adapts to fit practically any instrument without cutting**
- **Uses only 4 cubic feet of gas in 24 hours**
- **Operating pressure range 15-25 psi**

withstood Hurricane "Flossy"

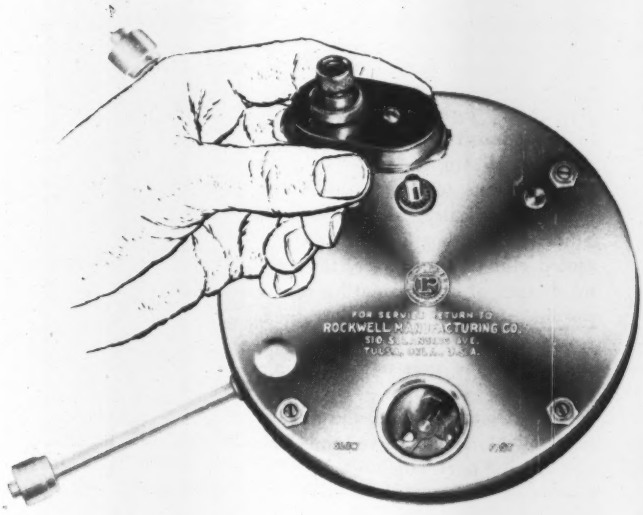
THE NEW ROCKWELL GAS DRIVE

A gas or air powered chart drive for all kinds of recording instruments—completely self-contained, self-starting.

Let's hope you will never need a chart drive that will run throughout a hurricane, but right now you can use the new Rockwell Gas Drive with profit to power remotely located instruments. You can forget the costly chore of periodic winding, for this drive is completely self-powered by the gas (or air) in the flowing stream.

The Rockwell Gas Drive is economical to run—it consumes only 4 cubic feet of gas every day. It's safe, too, for there is no venting problem. And it is built right into the case of a standard Rockwell chart drive and has all the interchangeability features of the spring wound design. It can be neatly fitted into practically any make intermitter, production timing instrument or recorder by using furnished adaptors for position and height. Speed changing turrets, which snap on to the main arbor, provide the utmost versatility in rotation rates. So with a stock of standard Rockwell Gas Drives, plus a selection of economical turrets, you can serve all your instrument needs.

Get full facts by writing Rockwell Manufacturing Company, Instrument Division, Pittsburgh 8, Pa.



The turret on top does the trick.

See how easy it is to convert a Rockwell Gas Drive to any of 10 different rotation rates.

The main arbor on this drive rotates once every 24 hours. Speed changing turrets are available to give 2-hour, 3-hour, 4-hour, 6-hour, 12-hour, 48-hour, 72-hour, 7-day, and 8-day rotation. No special tools or skills are required to convert to different rotation rates; the turrets snap into place.

GAS DRIVES, CHART DRIVES

another fine product by

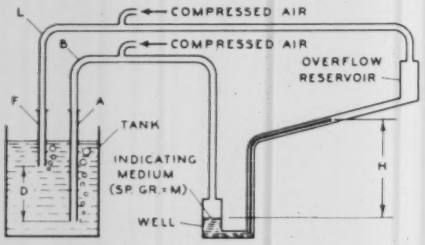
ROCKWELL

CIRCLE 33 ON READER-SERVICE CARD

briefs

Determining Specific Gravity Hydrostatically

Two separate compressed air supplies (controlled by flowmeters) introduce air into both static tubes. The distance between the static tubes, "D," is constant—and predetermined. Under these conditions, the manometer's indicating liquid (of known and selected specific gravity) will be displaced proportionately to a height, "H," which will remain stationary, so long



as both the specific gravity of the liquid tested and the flow of compressed air remain unchanged. Since the flow of the compressed air can be held constant, the displacement of the indicating liquid will change only when the specific gravity of the tested liquid changes . . . The displacement of the indicating liquid can be determined from the following formula:

$$H = \frac{D \times G}{M} - K \times \frac{D \times G}{M}$$

$$\text{or } G = \frac{H \times M}{D - (K \times D)}$$

(H= displacement of indicating medium, in inches; D= head of liquid from open end of high static tube to open end of low static tube, in inches; G= specific gravity of liquid in tank or vessel—units Sp. G.; M= specific gravity of indicating liquid in manometer —units Sp. G.; K = a constant—mathematically computed well drop, in inches.) Since values "M", "D" and "K" are definitely under control and are made constant, the value "H" can directly indicate the specific gravity . . . (*From new 88-page "Handbook of Hydrostatic Instruments," Petrometer Corp., 43-22 Tenth St., Long Island City 1, N. Y.*)

FOR THIS LITERATURE CIRCLE 154 ON READER-SERVICE CARD

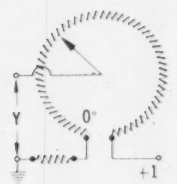
Basic Weight Scales

These scales indicate the weight, in pounds per ream, directly from the weight of a single sheet of paper, without any calculation. A 20 inch long pointer provides very fine sensitivity. Exceptionally fine, clear reading is easy with a dial that is 22 inches in length and located at eye level . . . (*From new 4-page Bulletin 321-BW, Thwing-Albert Instrument Co., Penn St., at Pulaski Ave., Phila. 44, Pa.*)

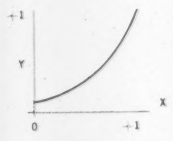
FOR THIS LITERATURE CIRCLE 155 ON READER-SERVICE CARD

Non-Linear Potentiometers

Precision potentiometer specifications call for voltage or resistance functions which do not maintain a linear output proportional to shaft rotation. Potentiometers of this type are termed non-linear, or functional. They are designed with special resistance elements to



Exponential (Log) — See Schematic 4



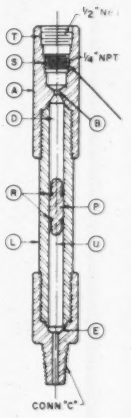
One Cycle (20 db. Log)
$Y = 10^{(X-1)}, \quad 0 \leq X \leq 1$

Two Cycle (40 db. Log)
$Y = 10^{2(X-1)}, \quad 0 \leq X \leq 1$

produce non-linear curves of infinite variety. Non-linear functions can be developed in all Spectrol models. Many of the more common curves are standardized . . . There are two fundamental categories of non-linear applications—voltage and resistance functions. Because the two are so closely related, differences should be noted . . . A potentiometer is basically a voltage pick-off device. With a voltage applied across the end terminals, a varying potential appears at the wiper proportional to the shaft rotation . . . A mathematical formula that defines every point along the entire curve, including end points, is desirable. Terms of the formula must be identified and given values. Examples of this type are trigonometric functions, algebraic, and exponential equations . . . (*From new 80-page Catalog 202, Spectrol Electronics Corp., 1704 South Del Mar Ave., San Gabriel, Calif.*)

FOR THIS LITERATURE CIRCLE 156 ON READER-SERVICE CARD

Excess Flow Check Snubber



In the event of instrument rupture, pressure upstream of the piston (U) forces the piston (P) to the opposite end of the cylinder (L), closing the port (B) and thus prevents loss of product, at pressures as high as 30,000 psi. Since the snubber is built into the sealed end of the device, there is no danger of contamination of its porous material with entrained solids suspensions which may be present in the pressure actuating medium.

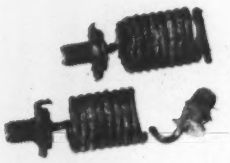
Compact and simple, the device is efficient, inexpensive and has one moving part which moves only a fraction of an inch, resulting in virtually no mechanical wear . . . (*From new 2-page leaflet, Chemiquip Co., 36 East 10th St., New York 3, N. Y.*)

FOR THIS LITERATURE CIRCLE 157 ON READER-SERVICE CARD

Engineered Dehydration in Pneumatic Systems

Moisture and calibrated springs ■
Clean air on low flow ●
Refrigifilter—new "package" ◆
Sponge explains dew point ○

■ What price calibration?



Above you see the apparent villain of a mechanical tragedy—with a plot all too familiar to industry. The picture shows two calibrated springs, true heroes of a pneumatic control system until they ran afoul of the real villains – moisture and sludge in the compressed air lines. Result? A fine set of precision springs ruined. Worse, failure of a well-engineered pneumatic control set-up with consequent malfunction of operating equipment.

Prevention could have been simple. A Hankison Condensifilter used to filter and dehydrate compressed air downstream of the receiver would have saved the springs, eliminated downtime and costly repairs. The owners of these springs are now using Hankison Condensifilters – a fact that fellow instrument engineers would do well to remember. Look into Bulletin 4158 describing Condensifilters.

● Not a trace

What low-cost desiccant dehydrators are designed to provide clean, vapor-free air or gas to pneumatic equipment

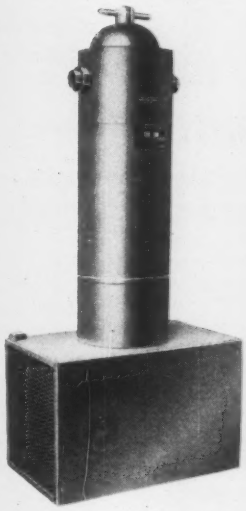
CM-1 Dehydrafilter. Cutaways show air inlet and outlet at top, desiccant and cartridge at bottom.

on dead end or low-flow service? Answer: Hankison Dehydrafilters.

With water adsorption capacity at 28%, and obtaining dew points as low as −67°F, Dehydrafilters effectively eliminate costly steam or electric tracing of the air lines. Several models are available. Capacities of 1 SCFM at 100 PSIG to 25 SCFM at 6000 PSIG can be accommodated.

◆ What's the point?

Dew Point, naturally! You can get a dew point as low as −30°F with the new Hankison Refrigifilter. It's the



compact, economical piece of equipment you need to prevent costly instrument and control foul-up. Combining the functions of a heat exchanger, condenser, separator, filter, and trap, the Refrigifilter requires *no on-site cooling water, and eliminates problems caused by ambient temperature variance.* Pneumatic systems are provided micro-clean, dehydrated, oil-free compressed air—systems are freed of the rust and sludge hazard that causes downtime and sometimes results in the complete failure or replacement of equipment. A unique heat exchanger pre-cools incoming air, and reheats the outgoing dehydrated air to reduce relative humidity and prevent sweating on the lines. *The equivalent of 9000 BTU/hr. of heat transfer is effected with refrigeration equipment rated for a maximum output of 4000 BTU/hr.* Condensate—oil and moisture vapor as well as entrained liquids—is discharged through the integral Mag-Pneu-Power Trap. Solid contaminants are removed by the specially designed filter cartridge. Maximum operating pressure of the unit is 300 PSIG (providing a −30°F atmospheric dew point), and pressure drop across the unit does not exceed 4 PSIG.

New Bulletin F-100 will be sent promptly upon request.

○ A Sponger

Are you sure you use the terms "dew point" and "relative humidity" correctly? If there's any doubt, write for your copy of "THE DEW POINT STORY." A simple bath sponge analogy clarifies these terms in simple, easy-to-read language.

HANKISON CORPORATION, COLLEGE & PIKE, CANONSBURG, PA.

There's something here that interests me. Please send me more information about

- ☐ Hankison Condensifilters
- ☐ Dehydrafilters
- ☐ Refrigifilters
- ☐ Dew Point

NAME _____ TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE _____ STATE _____

Hankison

CIRCLE 34 ON READER-SERVICE CARD

Here's the Simplest Diaphragm Pressure Switch

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	LINKAGES & BEARINGS which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

ASK FOR NEW CATALOG 9-PS FREE

PRESSURE SWITCH DIVISION

Barksdale valves

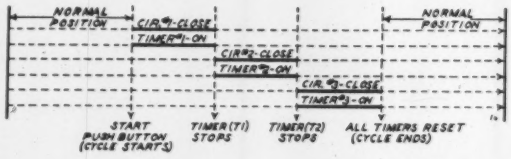
5125 Alcoa Avenue, Los Angeles 58, California

CIRCLE 35 ON READER-SERVICE CARD

BRIEFS—CONTINUED

Reset Timers

Three Load Circuits.—Each circuit closes and opens in sequency: (1) Start Push Button momentarily closed, timer (T1) starts, circuit No. 1 closes. (2) At end of preselected time period, circuit No. 1 opens, timer (T1) stops, (T2) starts and load circut No. 2 closes. (3) At end of preset time interval circuit No. 2

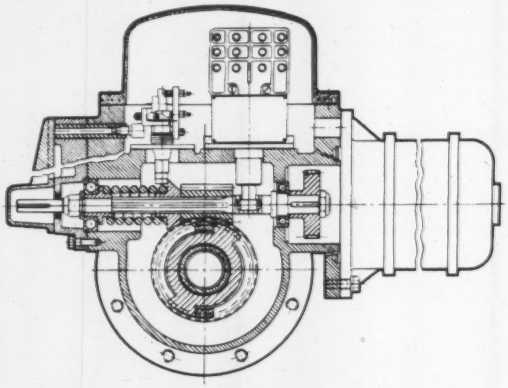


opens, timer (T2) stops, timer (T3) starts and circuit No. 3 closes. (4) At end of preset time interval circuit No. 3 opens, timer (T3) stops and all timers reset. (5) To reset before completion of time interval, momentarily depress stop push button. (6) If power fails, during timer operation, timer insantly resets and all circuits open . . . (*From 73-page binder, Lumenite Electronic Co., 407 South Dearborn St., Chicago 5, Ill.*)

FOR THIS LITERATURE CIRCLE 158 ON READER-SERVICE CARD

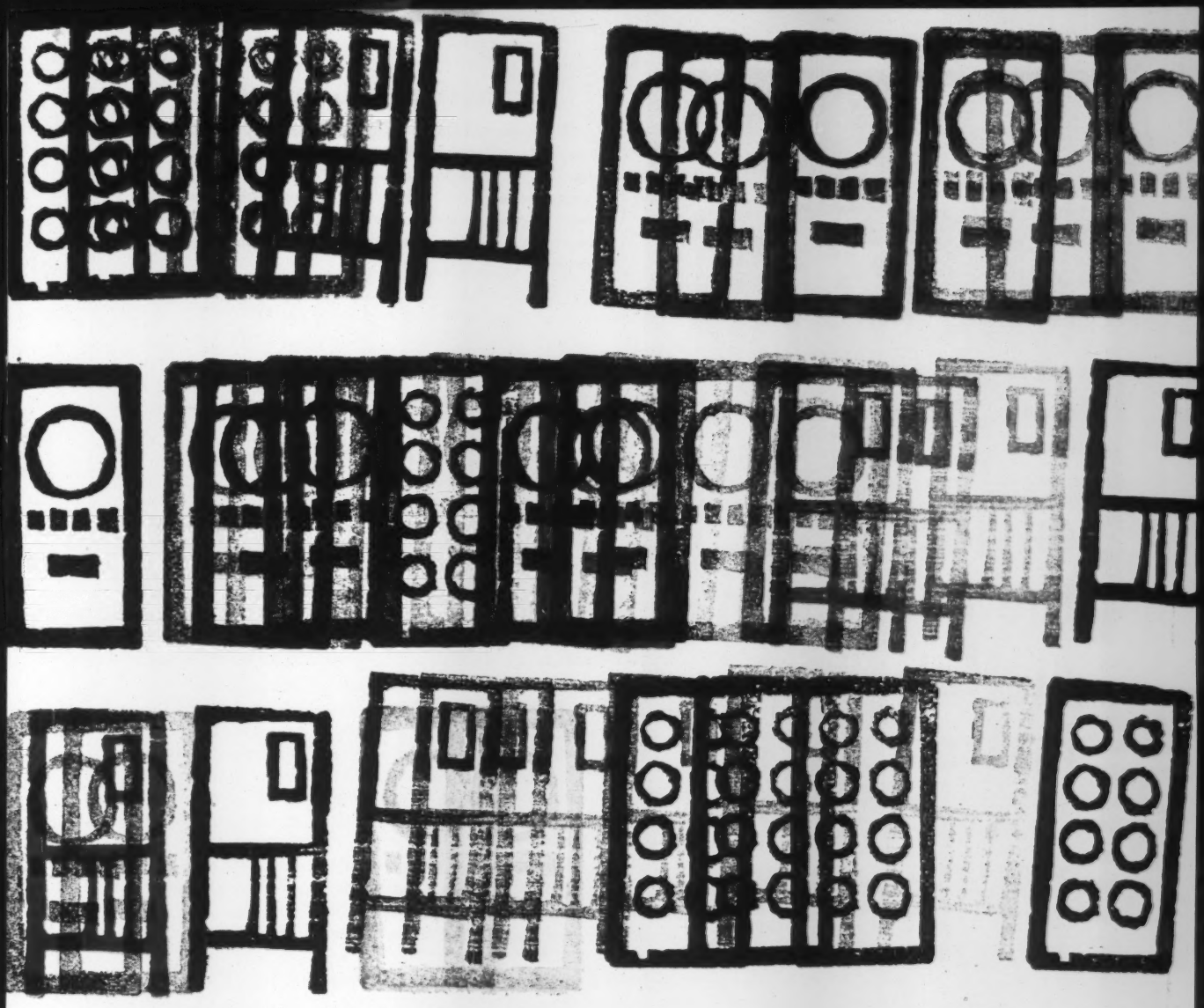
LimiTorque Valve Control

LimiTorque is an efficient, sensitive, automatic, power actuated device for controlling all types of valves, sluice gates and shipboard water tight doors. In the event of a power failure, LimiTorque can always be manually operated through a powerful hand-



wheel control . . . LimiTorque may be fitted to any size valve in almost any position or location and can readily be adapted to existing equipment. LimiTorque can be actuated by a wide range of power sources including electricity, hydraulic pressure, air or high pressure natural gas. Gas and oil pipelines utilize VHF Microwaves as a means of initiating operations of remote valves . . . (*From new 30-page Catalog L-550, Philadelphia Gear Corp., Erie Ave. & G St., Phila. 34, Pa.*)

FOR THIS LITERATURE CIRCLE 159 ON READER-SERVICE CARD

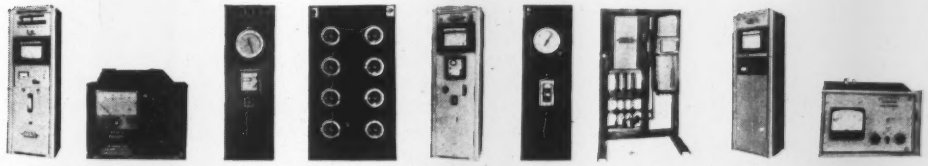


MSA CAN DO: COMPLETE LINE

instrumentation for process stream analysis

MSA can do, does, and will provide for you: complete line instrumentation for process stream analysis. The accurate, reliable kind. Standard or special. Simple or sophisticated. Instruments, sample systems, and accessories.

Please state your particular sampling problem —as well as the MSA Instrument of interest— when writing for descriptive literature.



M-S-A® LIRA® Infrared Analyzer Model 200 | M-S-A® LIRA® Infrared Analyzer Model 300 | M-S-A® Inert Gas Analyzer | M-S-A® Combustible Gas Analyzer | M-S-A® Thermatron Analyzer | M-S-A® Oxygen Indicator | M-S-A® Water Vapor Recorder | M-S-A® BillionAire® Analyzer | M-S-A® Process Refractometer

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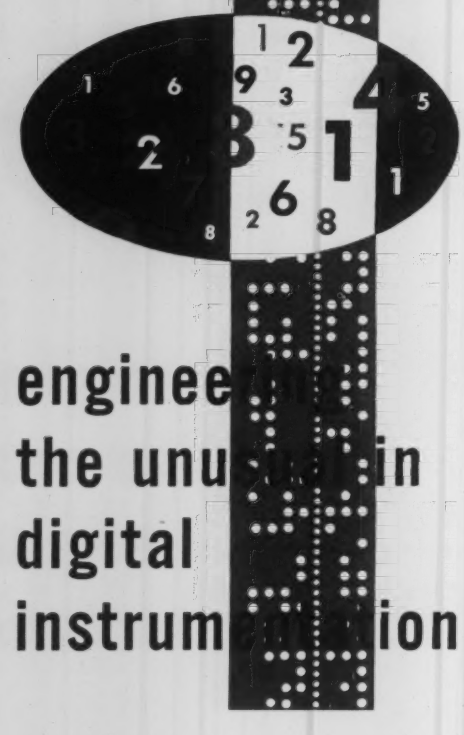
MSA®

INSTRUMENT DIVISION

Mine Safety Appliances Company

Pittsburgh 8, Pennsylvania

CIRCLE 36 ON READER-SERVICE CARD



engineer the unu in digital instrum ion

Peak engineering loads, tight delivery schedules, shortages of personnel . . . all place an added strain on overtaxed engineering facilities. If digital equipment engineering is part of this load, Franklin Electronics' Communications and Control Division can serve you best. Franklin's C & C Division, working in close cooperation with your engineering staff, designs and develops digital instruments and data systems to your specifications.

Whether the need is for a complete data acquisition and reduction system, a language translator, or a simple digitizer, you'll be pleased with how the C & C Division can ease your engineering load. But most of all, you'll be pleased with the final product . . . delivered on time . . . on a guaranteed performance basis.

Bulletin CC-220 describes the work of the C & C Division, its facilities, some of the equipment it has developed in the past . . . and how it can assist you now. Write for a copy. There's no obligation, of course.

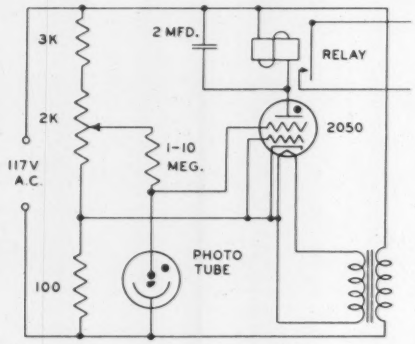
FRANKLIN electronics, inc.

COMMUNICATIONS AND CONTROL DIVISION
VAN NUYS, CALIFORNIA

CIRCLE 37 ON READER-SERVICE CARD

Phototubes

Photo electric devices divide themselves into three major families, with several subdivisions within each family: (1) photo emissive, (2) photo resistive, (3) photo voltaic . . . It has become accepted practice to refer to the photo emissive devices as phototubes and to reserve the name photocell for the photo resistive device . . .



Phototubes are diodes consisting of an anode and a cathode sealed inside a glass envelope which has been exhausted and into which, in some types, a small amount of a rare gas has been admitted.

Photo resistive cells . . . are much smaller and more rugged than any of the photo emissive types. Yet, their sensitivity exceeds all but the photo multiplier tubes in some cases. Excellent, long wavelength response, beginning in the visible red region and extending far down into the infrared region is typical of these cells . . . A photo operated relay using a gas phototube and a small thyratron is shown . . . (*From 6-page Brochure "Phototubes and How to Use Them." PA-227, CBS-Hytron, Danvers, Mass.*)

FOR THIS LITERATURE CIRCLE 160 ON READER-SERVICE CARD

Speed—An Automatic Coding System For The LGP-30

In the SPEED Compiling system, the techniques of preparing a problem for a computer are essentially reduced to the elementary rules of algebra. Techniques of scaling need not be considered as all work is done in floating point. In addition, all storage allocation is accomplished by the system thereby eliminating the need for learning special operations or addressing methods. When entering the problem description and the data, a standard typewriter keyboard is used . . .

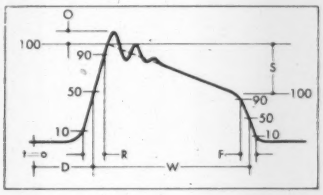
```
input
[ [a + b + c] x d + sin [a x t] ] : y
print y stop
```

The first information entered into a computer must always be a statement of the problem. In the SPEED system, the statement of the problem is a series of algebraic expressions as in the preceding example brackets [ ]; operations +, x, sin; and symboles a, b, c, d, t, and y are employed . . . (*From new 8-page Bulletin 507, Data Processing Div., Royal McBee Corp., Westchester Ave., Port Chester, N. Y.*)

FOR THIS LITERATURE CIRCLE 161 ON READER-SERVICE CARD

Pulse Generators

Pulse circuits have a transfer function (relation of output to input) in the time domain in the same fashion as sine wave circuits have a transfer function in the frequency domain. This function is expressed as the output of a circuit with a step function (zero rise time) input applied at zero time. . .

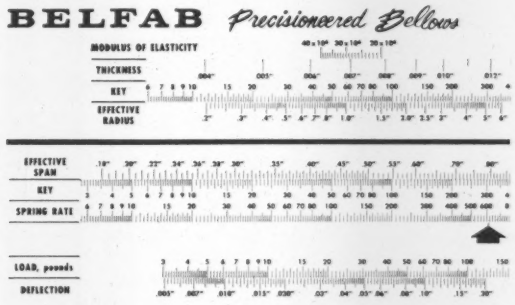


Pulse definitions are somewhat arbitrary but are generally accepted as indicated in Figure. R is the rise time, or leading edge time, commonly measured on the pulse leading edge for either pos. or neg. pulses. F is the fall of time or trailing edge time. D is the delay from a reference and W is the pulse width or duration. S is the top slope and is usually expressed in percent of leading edge 100% amplitude, as is the overshoot O . . . (*From new 50-page 1959/60 General Catalog, Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.*)

FOR THIS LITERATURE CIRCLE 162 ON READER-SERVICE CARD

Bellows Design

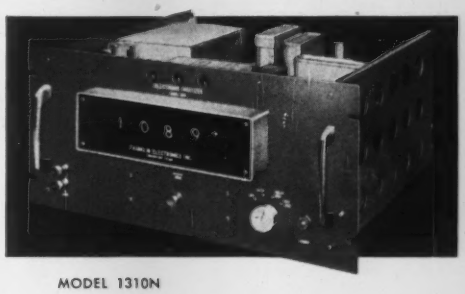
A metallic bellows of any type behaves, in part, like a helical spring. The spring rate (pounds of force per inch of movement) is a direct function of the elasticity modulus, and of approximately the square of the thickness of the material. It is also a function of the outside diameter and of the number of convolutions and their curvature . . . A bellows departs from the



simple helical spring analogy, however, in that it gets added "length" of material from the depth of the convolution. The depeer the convolution, the greater the length of spring material . . . One other factor is important. In a welded bellows, the shape of the walls of the convolution can be controlled. The convolution forms used are computed curves, exactly suited to the particular design. They may be simple or compound, with or without flats depending on the results desired. This represents a major advance in bellows technology . . . (*From new 20-page Bellows Design Manual and free Slide Rule, Belfab Corp., 94 Hobson Ave., Hamden, Conn.*)

FOR THIS LITERATURE CIRCLE 163 ON READER-SERVICE CARD

FRANKLIN SERIES 1300



MODEL 1310N

ANALOG-TO-DIGITAL CONVERTERS

indefinite long-term stability

± one count accuracy

. . . two good reasons why Franklin's Series 1300 instruments are preferred in dozens of demanding applications. But there's more . . .

Series 1300 Analog-to-Digital Converters are available in four basic configurations—off-the-shelf, ready-to-operate. Matching accessories perform additional functions—convert codes, extend sensitivity, provide for a-c input signals, furnish automatic features . . . give the engineer complete freedom in his data system design.

For all the facts, request Bulletin 606.

ANALOG-TO-DIGITAL CONVERTERS

MODEL	* INPUT SIGNAL	READOUT	POLARITY AND DECIMAL INDICATION
1310	000.0 TO 120.0 V DC	VERTICAL	NO
1310N	SAME AS MODEL 1310	IN-LINE (NIXIE)	YES
1321	000.0 TO 120.0 V DC, 1 TO 100,000 MMF	VERTICAL	NO
1321N	SAME AS MODEL 1321	IN-LINE (NIXIE)	YES

* FOR SENSITIVITIES UP TO 100 MICROVOLTS PER DIGIT, SEE THE FOLLOWING LISTING.

FUNCTION AND RANGE EXTENDING AMPLIFIERS

MODEL	GAIN RANGES	GAIN SWITCHING			AUTOMATIC POLARITY
		LOCAL	REM.	AUTO.	
319RA	1, 10, 100, 1000	YES	NO	YES	YES
319R	1, 10, 100, 1000	YES	YES	NO	NO
319	1, 10, 100, 1000	YES	NO	NO	NO
318RA	1, 10, 100	YES	NO	YES	YES
318R	1, 10, 100	YES	YES	NO	NO
318	1, 10, 100	YES	NO	NO	NO

FRANKLIN electronics, inc.

BRIDGEPORT • PENNA.

CIRCLE 38 ON READER-SERVICE CARD

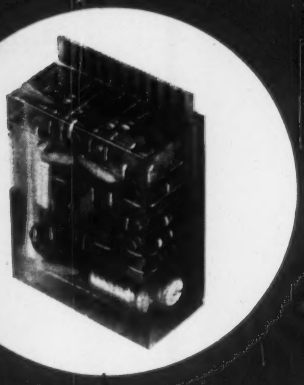
!!! NEW !!!

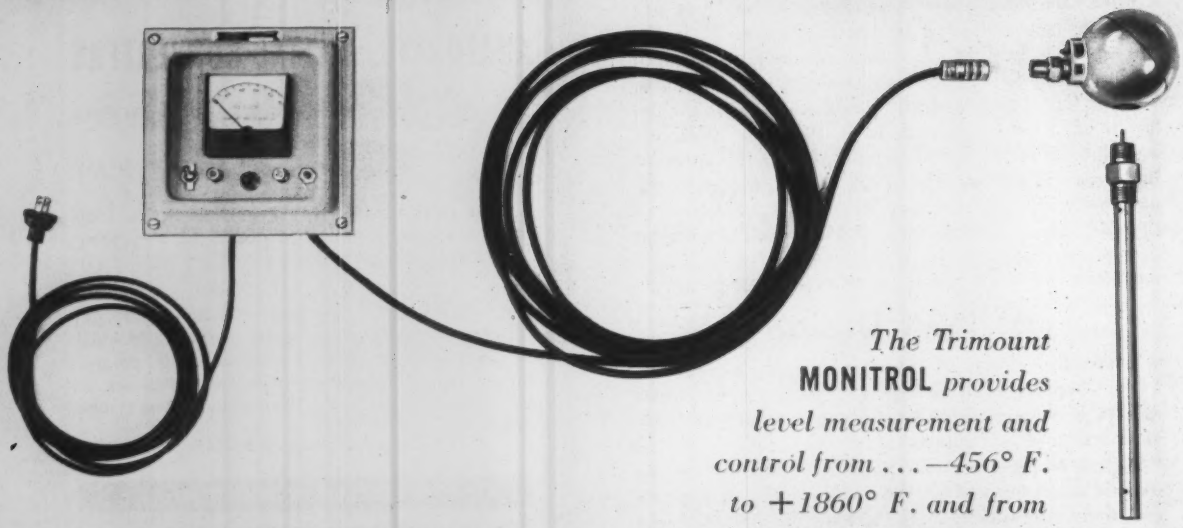
from TRIMOUNT

the finest, highest development

in level indication and control!

the MONITROL





The Trimount **MONITROL** *provides level measurement and control from . . . —456° F. to +1860° F. and from 1.0 micron to 10,000 psi.*

The Trimount MONITROL is an ultra-sophisticated solid state device operating on the principle of a change in the electric field displayed by any material. This change is a linear function of material or liquid level. The MONITROL represents the highest advancement in the art of level measurement and control.

RELIABILITY AND SIMPLICITY . . . Circuitry is completely transistorized and encapsulated to withstand extremes of vibration, moisture or shock.

LINEARITY AND SENSITIVITY are achieved in the MONITROL since the unit incorporates Trimount's unique and exclusive Static E detector.

ACCURACY AND REPEATABILITY were designed and engineered into the MONITROL . . . the unit performs efficiently under the most extreme conditions. The MONITROL can be used with liquids, solids and viscous materials.

MEASUREMENT AND CONTROL functions are combined in one compact, easily operated unit. Distance between probe-relay Control and power-supply readout can be as much as two miles with no loss in accuracy and reliability!

SPECIFICATIONS

SENSITIVITY ..... 3 Microamps per micromicrofarad.
LINEARITY ..... Better than 1%.
STABILITY ..... Better than .5% for ± 10% line voltage fluctuation.
OUTPUT ..... 125 Millivolts into 2,500 ohms.
METER ..... 50 microamp full scale.
Scale Graduated 0-100% high and low control points, adjustable over entire range.

Write for further information . . .

TRIMOUNT INSTRUMENT COMPANY

CIRCLE 27 ON READER SERVICE CARD

Lockheed's endless-loop tape recorders

DEVELOPED FOR SPACE COMMUNICATIONS, the recording capabilities of Lockheed's new endless-loop tape recorders are creating interest wherever the need exists for stored data in a critical environment. The original design is now operational in delayed and continuous recording and playback of stored data. Its endless-loop mechanism records and plays back in the same direction of tape travel . . . without rewind.

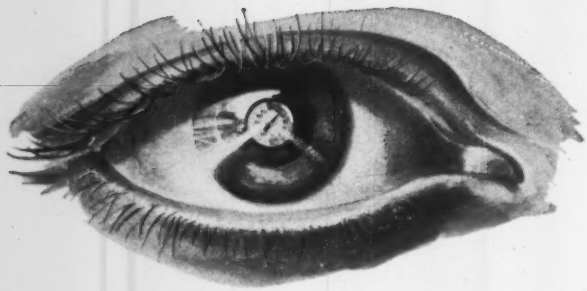
Variations of this lightweight, small size, low power consumption unit are available in a wide range of tape speeds and multiplicity of tracks. For more information on advanced recording techniques to meet your recording needs, write Marketing Branch, Lockheed Electronics and Avionics Division, 6201 East Randolph Street, Los Angeles 22, California.

Look to Lockheed for LEA*Dership in Electronics*

LOCKHEED ELECTRONICS & AVIONICS DIVISION

REQUIREMENTS EXIST FOR STAFF AND SUPERVISORY ENGINEERS

CIRCLE 40 ON READER-SERVICE CARD



What you read is right

The new, patented Maxivision dial on American Bi-Metal Thermometers eliminates the perspective effect of usual pointer-above-dial construction. No parallax! Readings are sure, sharp and accurate – exact working temperatures are always right before your eyes. It is a two-level dial. A raised outer ring, set close to the cover glass, carries the graduations. The index type pointer is on the same plane as the outer ring, with the numerals on a lower level.

What you read is right when American Bi-Metal Thermometers with anti-parallax Maxivision dial are installed at important check points on your processing facilities. Mounting styles, dial sizes, temperature ranges and stem lengths are available to meet the most exacting requirements. Let your nearby industrial distributor help you select the best combination for each location.

American Bi-Metal Thermometer with Maxivision Dial. Suitable for indoor or outdoor service.

MAXWELL MANNING & MOORE INC. MM TRADE MARK

A2-58R

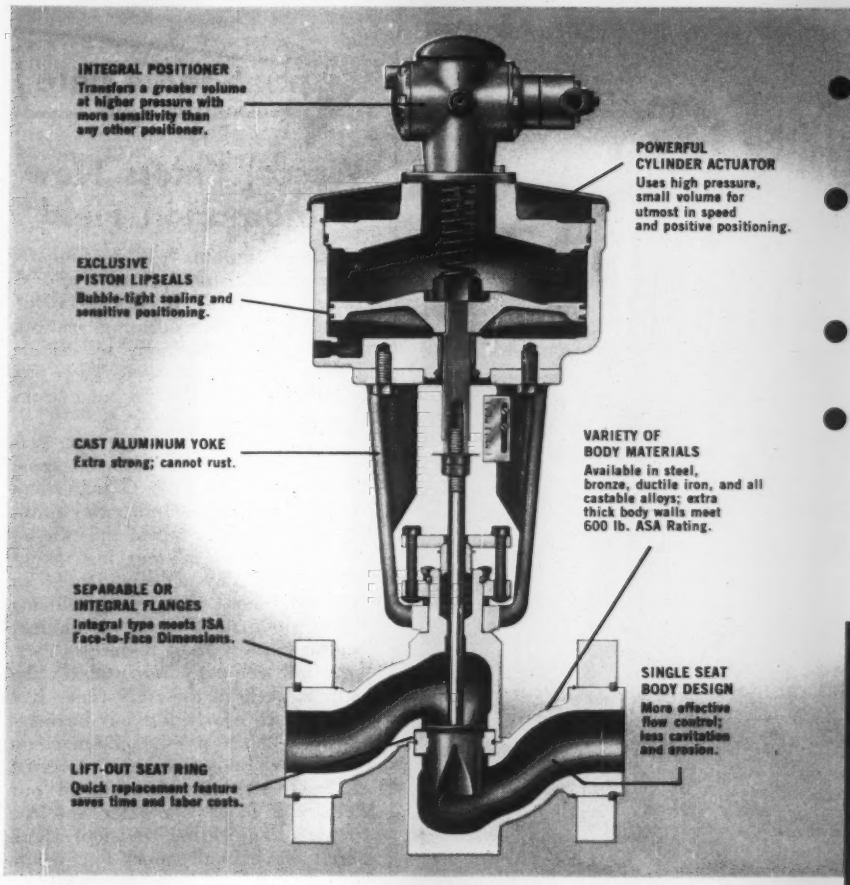
AMERICAN INDUSTRIAL THERMOMETERS

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 41 ON READER-SERVICE CARD


INTEGRAL POSITIONER
Transfers a greater volume at higher pressure with more sensitivity than any other positioner.
POWERFUL CYLINDER ACTUATOR
Uses high pressure, small volume for utmost in speed and positive positioning.
EXCLUSIVE PISTON LIPSEALS
Bubble-tight sealing and sensitive positioning.
CAST ALUMINUM YOKE
Extra strong; cannot rust.
VARIETY OF BODY MATERIALS
Available in steel, bronze, ductile iron, and all castable alloys; extra thick body walls meet 600 lb. ASA Rating.
SEPARABLE OR INTEGRAL FLANGES
Integral type meets ISA Face-to-Face Dimensions.
SINGLE SEAT BODY DESIGN
More effective flow control; less cavitation and erosion.
LIFT-OUT SEAT RING
Quick replacement feature saves time and labor costs.

- **Guaranteed tight shutoff at any pressure or temperature**
- **Simplified construction means less maintenance and fewer replacement parts**
- **Quick delivery in all sizes 3/4" thru 6"**
- **Available in straight-thru, three-way and angle design; also with hand-wheel actuators, manual override, radiation fins and other optional features**

Partial List of Conoflow LB Valve Users:

ALUMINUM CO. OF AMERICA
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USERS FROM COAST TO COAST SPECIFY

"CONOFLOW LB VALVES

for Automatic Control that's Headache-Proof"

When company after company switches to Conoflow LB control valves—and constantly reorder—there must be a reason. Leading manufacturers use Conoflow LB valves because they want headache-proof control—and they get it. Specify Conoflow LB valves for performance, economy and dependability—*complete* satisfaction. For additional information telephone your Conoflow representative (located in principal cities); or write to Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa. for Bulletin LB-3.

CC902

CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

SUBSIDIARY WALWORTH

CIRCLE 42 ON READER-SERVICE CARD

AVAILABLE NOW

MODULARIZED RANDOM ACCESS MEMORY

8 μ SEC. CYCLE TIME

COMPUTER CONTROL COMPANY announces the availability of a new all transistor, coincident current, ferrite core, high speed random access memory

FEATURES:

- Word capacities up to 4096 words (you specify).
- Word lengths up to 40 bits/word (you specify).
- Access time to any address — 4 μsec.
- Cycle time — 8 μsec.
- Modular plug-in etched circuits.
- High reliability and ease of maintenance.

Write for eight-page Bulletin TCM

COMPUTER CONTROL COMPANY, INC.

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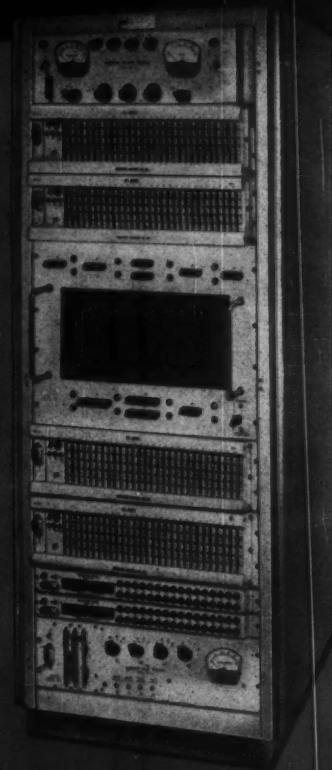


CIRCLE 43 ON READER-SERVICE CARD

panhandle pete

Wesco! Enters New Automation Field

It was with a sense of great opportunity and decision that we WESCO! executives entered W. K's office for our monthly brainstorming session, (we call each other only by initials at these sessions so as to keep our importance at the top of each brain while it is storming).

These monthly brainstorming sessions are all that *Fortune* magazine makes them out to be. You readers of this column know how many problems WESCO has solved this way—how we changed all our instrument peddlers into systems engineers so they could meet company presidents rather than instrument mechanics; how we used market research to expand our company into exactly the right markets at the right time; like the time we nearly lost our business when we had to pay income taxes on our Himmelrakets, and how we saved WESCO! only by the skin of our teeth, the O. J. Computer and the Systems Engineering Division, which barely lost enough money to save the company; how we upgraded our entire profession by proper use of first letters, alphabetical appelations, and slogans.

"We can face the future unafraid," said our genial sales manager, W. K. (that's Waldo Klapsaddle), as he smiled at our Chief Engineer J. L. (John L. Bus Wallace), Flight Engineer A. F. (Andy Francy), Director of Research O. U. A. (Otto U. Alles), Engineer, E. F. (Elmer Flannelgurdle) and me P. P. (instrument pedd—oops, systems engineer).

"I'm just a bit concerned about the future," counters E. G. (that's really Elmer), "what with Khrushchev liable

The Automatic Factory

by June, et al . . . a fresh viewpoint on what "manless factories" can be . . . free from the generalities, and misconceptions so prevalent on this subject. Cloth, 88 pages, 1955, $1.50.

Nuclear Reactors for Industry and Universities

edited by E. H. Wakefield. The several distinguished authors and editor Wakefield cover types, availability (1954), operation, protection, control, experiments, legal aspects, and present a detailed cost study. Cloth, 92 pages, 1954, $2.00

Instruments Publishing Co.
845 Ridge Ave., Pgh. 12, Pa.

to sweet talk our innocent Ike into giving him Fort Knox, and us having only recently increased our losses in systems engineering to offset our profits in Himmelrakets. I have a terrible feeling of insecurity."

"You are worrying unnecessarily," says A. F., "The market for Himmelrakets will be good as long as a man remains without the right of self-determination anywhere in the world."

"But just in case, wouldn't it be smart to expand our lines into a profitable industrial field,?" queries J. L.

"That is indeed a brainstorm," replies O. U. A., "but we already have an Industrial Systems Division, a Systems Systems Division, a Computer Division, and a Kanarienvogle Analyzer Division. What have we missed?"

As if waiting for this leading question, J. L. whips out the editorial from a leading trade journal and reads: "A major misconception of today is the widely held view that automation is only for giant companies, who can afford the millions of dollars it takes for systems engineering and data logging. This is not true."

"Eureka," shouts A. F. in Greek. "You are a genius. Every small company also can't afford not to spend those millions either. Why increased efficiency, rapid and more accurate data is a *sine qua non* today," switching from Greek to Latin. "Nobody can do without a *sine qua non*—get out the order pads."

"No, no," say J. L., "you are off the beam. Nobody has figured out how to make a small company spend money it doesn't have. Only the larger company can do this. You are on the wrong track."

"Then why did you bring up the entire subject," snarls A. F., justifiably chagrined that neither his Greek, Latin nor profundities were appreciated. "Solve your own problem, my brain quits."

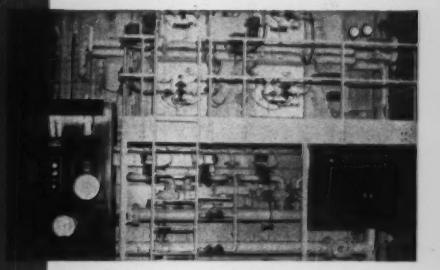
"Which is what I have done," replies J. L. "WESCO! will market a complete line of automation equipment for the small company, proving that automation is for the small company as much as the large. These equipments will include what every small company needs for automation —hand drills, ratchet screwdrivers, torque wrenches, counters, thermometers, pressure gages, rotameters, why the list is endless, and this is a virgin field of automation that has been completely abandoned by all other instrument manufacturers! Nobody's been selling such stuff for years. Let's go after it."

Panhandle Pete

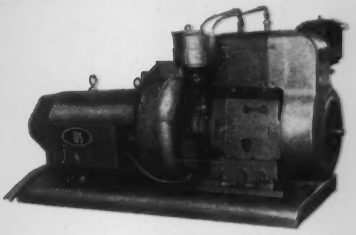
DOUGLAS AIRCRAFT

TULSA DIVISION

eliminates the risk of flame-outs caused by power outages with . . .



MICRO-POWER



In plants like Douglas Aircraft Company, Inc., in Tulsa, Oklahoma, where a continual supply of steam is vital to production processes, every precaution must be taken to assure against the hazards of boiler flame-out. To safely regulate the shutting down of its burners in the event of flame-out, the company utilizes highly sensitive electric controls. Since these flame failure controls *are* electric and must depend on a constant, unwavering power supply for successful operation, a further precaution is taken . . . MICRO-POWER.

At Douglas Aircraft in Tulsa, Micro-Power serves as the dependable rear guard to the boiler room. It provides a constant source of steady, independent electrical power as required by the safety controls, thereby eliminating voltage fluctuations and protecting against power failure.

MICRO-POWER IS ALSO USED . . .

- on microwave installations for communications, for remote control, for telemetering.
- for refinery and chemical process indication and control.
- by public utilities for protective relaying, telemetering and load distribution.

MICRO-POWER PROVIDES . . .

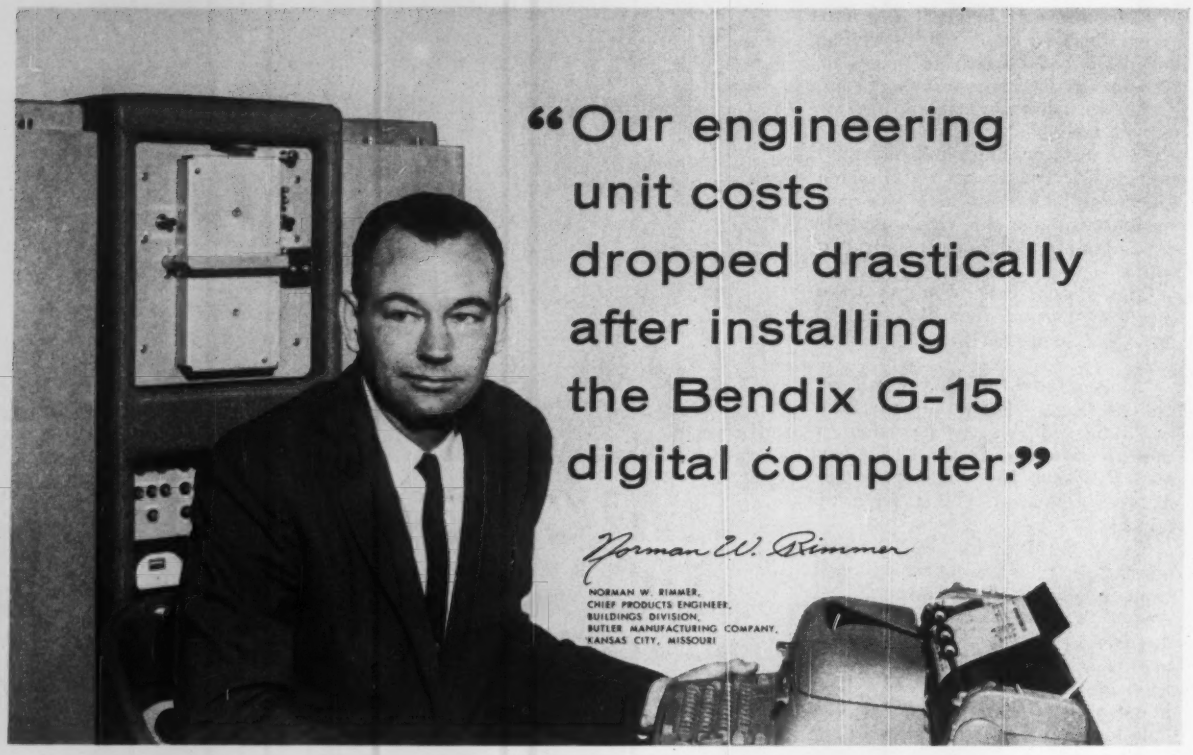
- a constant source of electric power.
- voltage and frequency at usable value during transfer from motor to engine.
- stable voltage output.
- flywheel starting — no storage batteries.
- electrical isolation from commercial source — no voltage dips or peaks to affect microwave equipment — no transfer switch.
- return to motor drive after commercial power restoration without interruption of voltage.

The Douglas Aircraft Company, Inc., Tulsa Division, "Micro-Power" application is just one of a wide range of uses for this versatile standby power unit. For complete product and application information, call or write . . .

UNITED STATES MOTORS CORPORATION
MICRO US POWER
OSHKOSH • WISCONSIN

UNITED STATES MOTORS CORPORATION
102 West Fifth Avenue
OSHKOSH, WISCONSIN

CIRCLE 44 ON READER-SERVICE CARD


"Our engineering unit costs dropped drastically after installing the Bendix G-15 digital computer."
Norman W. Rimmer
NORMAN W. RIMMER,
CHIEF PRODUCTS ENGINEER,
BUILDINGS DIVISION,
BUTLER MANUFACTURING COMPANY,
KANSAS CITY, MISSOURI

Butler's progressive engineering program requires a fast, versatile, and low-cost computer. It must handle complex structural problems and still be simple enough to be used by engineers with no programming experience. The computer's mission: cut engineering unit costs. *"Our own survey proved that the Bendix G-15 digital computer could best do this job,"* says Mr. Rimmer, *"and it does."*

For Butler, part of the cost-cutting versatility of the G-15 stems from the variety of programming methods they can use. For the solution of repetitive problems at highest speeds, they use the machine language system. With the simplified Intercom 1000 system, the entire staff uses the computer for structural design problems. This versatility also means the G-15 can be used for business data processing as well as scientific and design calculations.

Butler is also pleased with the expandability of the G-15. They know that as their computing requirements grow, they can add magnetic tape units, punched card equipment, digital differential analyzers, plotters, and other accessories. Remember, however, that the basic G-15, which includes a unique photo-electric tape reader-punch and alphanumeric typewriter, is more than adequate for most problems.

Find out more about this computer — the *only* medium-scale computer in the low-price field. Inquiries regarding specific applications are welcomed.

Bendix® Computer

DIVISION OF BENDIX AVIATION CORPORATION

DEPT. J-16
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Here's your best combination to sell the entire instrument-control-systems market

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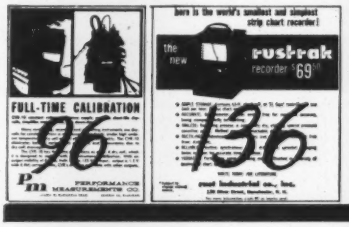
Produces more quality sales leads than any other monthly publication in the field. The heavy figures shown below indicate the number of sales leads from one insertion. Readers' direct-to-advertiser leads not included.



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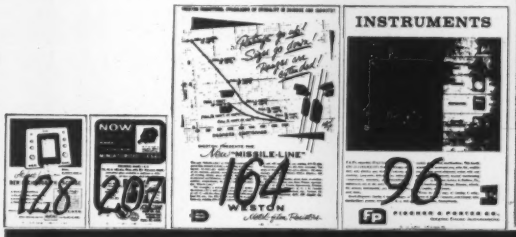
Serves the laboratory, OEM and industrial market. Over 90,000 copies distributed to customers of equipment and component distributors who pay the publisher for each recipient. The industry's only tabloid. Issued bi-monthly.



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The bi-monthly, king-size magazine devoted to design and application of instrumentation and control in the military equipment market. Read by over 30,000 qualified verified men in government and military-end-product manufacturing industry.

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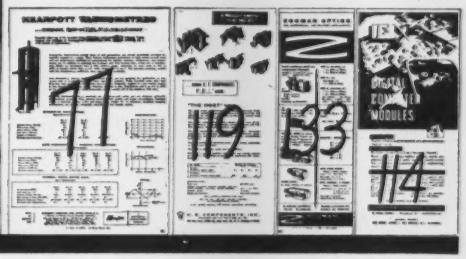
UNDUPLICATED COVERAGE . . . 150,000 USERS AND BUYERS

Use all 3 publications for complete coverage of the industrial and military instrument/control/systems market. A 10% discount applies to equivalent space used in two or all three publications.



Write for Market-Media data, and sample miniature "marked copy" of IAN and MSD.

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845 RIDGE AVE., PITTSBURGH 12, PA.

Representatives in

New York, Chicago, Cleveland, Boston, Kansas City, Dallas, Los Angeles, San Francisco, Philadelphia, St. Louis, London, England.

THE PRACTICAL LOW COST ANSWER TO MULTI-CHANNEL OSCILLOGRAPHIC RECORDING PROBLEMS ··· SANBORN INTRODUCES THE FIRST OF THE 950 SERIES ··· THE 950-1500 SYSTEM ··· FOR FLOATING OR GROUNDED INPUTS FROM 10 μV TO 0.1 VOLT PER DIVISION ··· ALL-TRANSISTORIZED ELECTRONICS MOUNTED BEHIND A SINGLE 7" HIGH PANEL ··· FLUSH-FRONT RECORDER WITH 9 ELECTRICALLY-CONTROLLED CHART SPEEDS ··· IMPROVED, RUGGED GALVANOM-ETERS ··· CLEAR, INKLESS TRACES ··· RECTANGULAR COORDINATE RECORDINGS ··· ALL IN A SYSTEM DE-SIGNED SPECIFICALLY TO PROVIDE GREATER ECONOMY AND ACCURACY WHEN SYSTEM FLEXIBILITY IS NOT REQUIRED.

Additional features of the 950-1500 include: common power supply, built-in MOPA, front and rear inputs, easily serviced plug-in circuit cards, adaptability for use with other readout devices. When many channels are constantly in use for floating or grounded high gain inputs the simplified 950-1500 design assures dependable operation, yet at much lower "per channel" cost.

Complete details are available from Sanborn Sales-Engineering Representatives located in principal cities throughout the U.S., Canada and foreign countries.

SPECIFICATIONS

INPUT	100,000 ohms, all ranges, floating and guarded.
OUTPUT	400 ma. full scale, 15 ohms nominal load, ungrounded
LINEARITY	±0.4%
SENSITIVITY	10, 20, 50, 100, 200, 500, 1000 and 2000 uv per chart div
COMMON MODE REJECTION	100 db, min. dc
FREQUENCY RESPONSE	0-100 cps within 3 db at 10 div peak to peak. 0-50 cps within 3 db at 50 div peak to peak.
NOISE	¼ div peak to peak maximum.

(All data subject to change without notice)

NEREM '59 Comm. Armory, Boston, November 17, 18, 19.

SANBORN COMPANY

INDUSTRIAL DIVISION 175 Wyman Street, Waltham 54, Massachusetts

CIRCLE 47 ON READER-SERVICE CARD

book reviews

Guide du Controle Industriel (Industrial Control Guide), second edition, [c 1959] Editions B.P.I., 79 Avenue des Champs-Elysées, Paris 8°, France, 484 p., 8½", clothbound Fr. 2,700. Contains alphabetical index of instruments and trademarks; classified lists of measuring, testing, and lab instruments, control and automation systems, components and accessories; also catalog of French manufacturers, importers and representatives of foreign manufacturers, with English subtitles.

Absperrorgane in Rohrleitungen (Manual Control Elements in Pipelines) by Walther Volk, [c 1959] Verlag Springer, 3 Heidelberger Platz, Berlin-Wilmersdorf (West Berlin), 178 p, 9", clothbound DM 25.50. Book reflects the difference in the American and German approach to the subject in that it contains descriptions of *special* hand-operated elements of many designs used in a pipeline, while the basic American classifications of globe valves, gate valves, cocks, etc. are hardly mentioned. Besides illustrations and descriptions, much theory in form of strength and force calculations (including calculus) is used. Chapter on butterfly valves will prove valuable to specialists.

A Short Dictionary of Mathematics, by C. H. McDowell, [c 1957] Philosophical Library, Inc., 15 East 40th St., New York 16, N. Y., 63 p., 7¼", clothbound $2.75. Divided into two parts (Arithmetic and Algebra; and Plane Trigonometry and Geometry), the book describes the most common terms in uncomplicated language and examples.

Anwendung von Rechenmaschinen bei der Berechnung von Regelvorgaengen (Application of Computers in Calculations of Automatic Control Systems), edited by W. Oppelt [c 1958] R. Oldenbourg, 145 Rosenheimer Str., Munich, West Germany, 128 p., 9¼", clothbound DM 16.80. Collection of papers read at the Conference of the Committee for Control Mathematics of the Society for Applied Mathematics and Mechanics (Fachausschuss Regelungsmathematik der Gesellschaft fur angewandte Mathematik und Mechanik, GAMM) held in Dusseldorf November 8, 1957. Includes a paper read in English on "A Simple Graphical Method for Deconvolution" by J. B. Reswick, Cambridge, Mass., and

(*Continued on p.* 1505)

the world's most expensive inch of recording tape

There's no question about it—if there were a dropout in this inch of tape it could cost you plenty. That's why our customers invariably demand perfection from our EP Audiotape —the *extra precision* magnetic recording tape for computers, automation, telemetry and seismography.

Audio Devices' battery of Automatic Certifiers is one of the unique means used to make sure EP Audiotape always meets customers specifications. The Automatic Certifier records and plays back every inch of the EP Audiotape under test. These tests can be so demanding that if the tape fails to reproduce just *one* test pulse out of the 40 million put on a single reel, the entire reel is rejected. There are no *if's, and's,* or *but's.*

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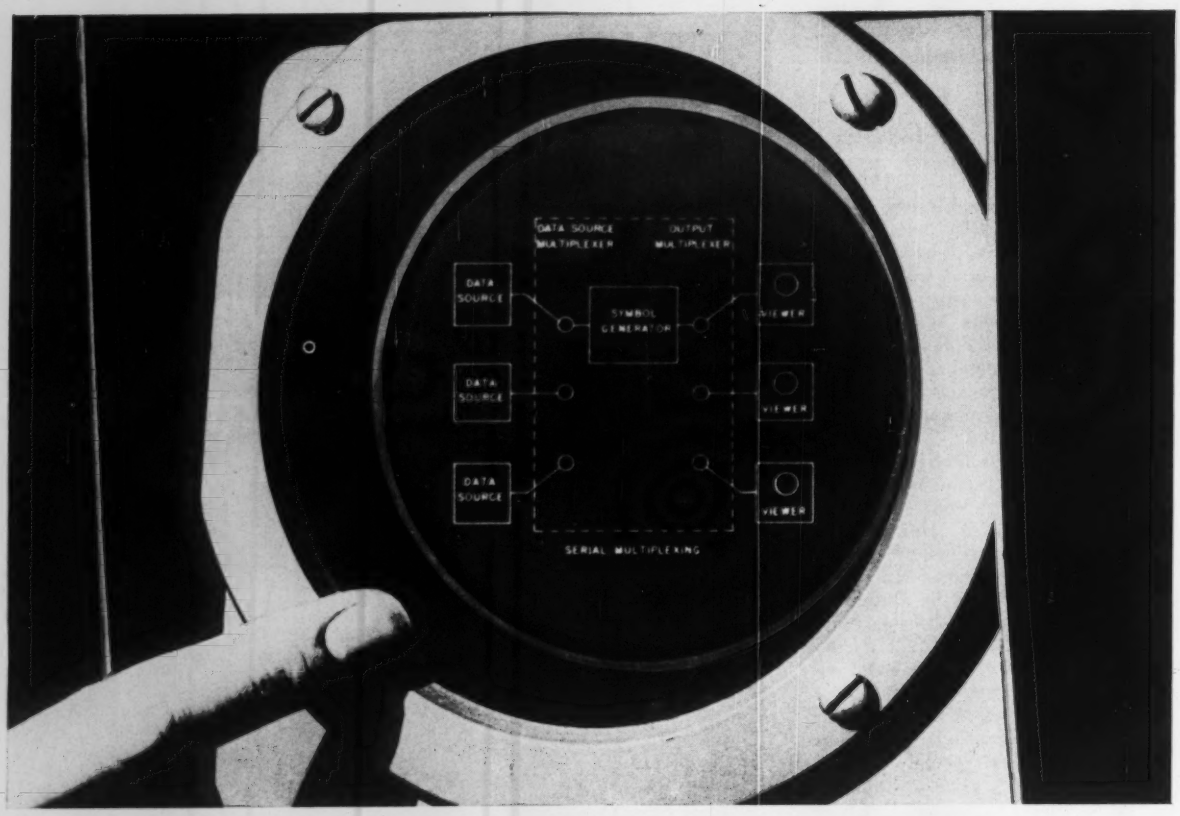
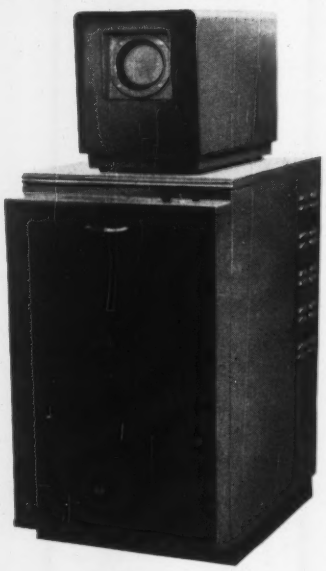


NOW . . . a complete data display system at unusually low cost.

NOW . . . by using LFE's exclusive SM Symbol Generator and Viewers you can custom design a complete data display system at unusually low cost. Only *one* symbol generator is required to operate any number of viewers . . . by series or parallel multiplexing . . . each with a different display. No other display system offers this flexibility. The result is exceptionally low cost.

The SM translates coded data into the written word from any digital data source . . . computers, tape units or teletype lines. Any number of sources can supply data to the same viewer, or each viewer can be attached to one source only . . . both viewers and source can be remote. The SM quickly generates and displays alpha-numeric characters, arbitrary or abstract symbols, graphs, charts or maps. Display rate is 20,000 characters per second . . . more than 64 different characters . . . 600 characters per display . . . accepts data at non-uniform rates. Display can be held indefinitely until erased. For complete specifications write for Bulletin 81.



SYMBOL GENERATOR AND VIEWER

Computer Products Division

LABORATORY FOR ELECTRONICS, INC.
1079 COMMONWEALTH AVENUE, BOSTON

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BOOKS

Continued from page 1503

other papers on applications of analog computers by Austrian, Belgian, German, and Italian scientists.

Organic Chemistry by Ray Q. Brewster and William E. McEwen, second revised edition, [c 1948, 1949, 1959] Prentice-Hall, Inc., Englewood Cliffs, N. J., 401 p., 9″, clothbound $10.00. Subtitle calls book "A Brief Course" and preface allots one semester or two quarters to the student. The electronic theory has been utilized in the explanation of the properties of various classes of compounds.

Electronic Digital Computers by Charles V. L. Smith, [c 1959] McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N. Y., 443 p., 9″ clothbound $12.00. Book describes basic principles of digital computers from the first machine developed at the Institute for Advanced Study. Assembly of basic circuits and interconnections are shown without going too far into the engineering. A large chapter is devoted to Boolean algebra, but it is not a theoretical treatise.

NEW MINIATURE PRESSURE TRANSDUCER BY COLVIN

- Only one inch square – one inch long
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35 G to 5000 CPS 0-3 to 0-400 psi
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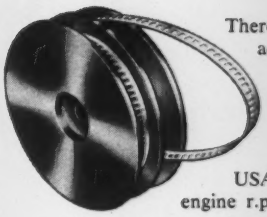

There's solid assurance in the high accuracy of Howell Instrument's Ta'Pot®, the "tape-slidewire" potentiometer used as the key measuring unit to check, *before* launch, The Martin Company's USAF TM-76 "Mace" engine r.p.m. and temperature systems– and which is the go/no-go control *during* launch.

The Ta'Pot is a straight wire (or helically wound!), embedded within the edge of a polyester tape. With calibration printed on the tape, this 12-feet long slidewire pot has up to 1200 readout scale points; or it may be geared to an in-line counter, and servo-driven in either case. *Or* the Ta'Pot may be manually operated for exact readout of functions...or for control of functions...or for computer inputs. Electronic calibration of Ta'Pot slidewires regularly achieves better than 0.05% conformity to either linear or non-linear functions. *The Ta'Pot is presently used in test cells, in jet engine analyzers, in jet aircraft cockpits and in a host of other critical applications.*

TA-POT®

HOWELL INSTRUMENT COMPANY
3101 Trinity Street, Fort Worth 7, Texas

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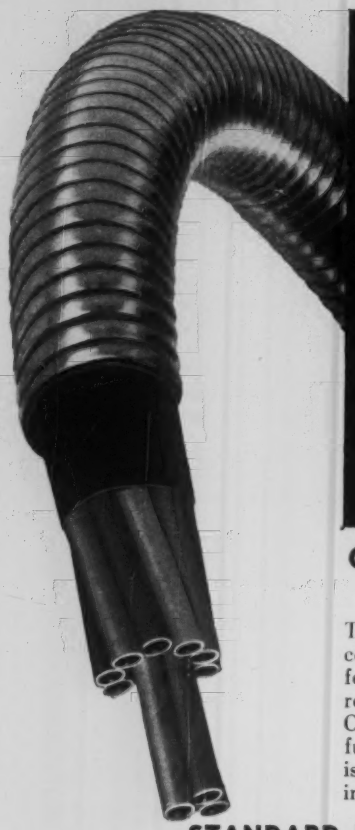

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POLYETHYLENE INSTRUMENT TUBING

Costs Less—Is Easier To Install

SIX DIFFERENT TYPES TO MEET YOUR SPECIFIC NEED

CRESCENT POLYETHYLENE MULTITUBE is 2 to 37 precision Polyethylene tubes *spirally cabled* together for greatest flexibility. The tubing assembly is protected against mechanical injury by an interlocked galvanized steel armor, Polyvinyl Chloride sheath, or other sheaths, as below.

CRESCENT POLYETHYLENE PRECISION INSTRUMENT TUBING

TYPE P is manufactured from the best high molecular weight virgin Polyethylene compound and TYPE XP of high modulus virgin Polyethylene compound selected for their superior resistance to environmental stress cracking and aging. Extensive research, improved manufacturing methods and rigid test standards have developed CRESCENT Polyethylene tubing to its present level of highest quality. It is furnished as single tubing in ¼", ⅜" and ½" sizes in up to eight bright colors. It is used exclusively in manufacturing CRESCENT POLYETHYLENE MULTITUBE in types as follows:

STANDARD TYPES

TYPE PA—Interlocked metallic armor provides complete mechanical protection.

TYPE PAT—Polyvinyl chloride sheath over the armor adds corrosion protection for the armor. Can be buried in the earth.

TYPE PT—PVC sheath gives limited mechanical protection. For use in troughs, trays or conduit.

SPECIAL SERVICE TYPES

TYPE XPT-U—Extra heavy PVC sheath over high modulus TYPE XP tubing permits direct burial, or use above ground where subject to moderate abuse.

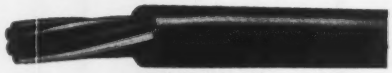
TYPE XPT-F—Same as XPT-U with heavy asbestos braid and outer PVC sheath. Provides time delay in event of flash fire.

TYPE XPT-FA—Same as XPT-U with heavy asbestos braid and interlocked metallic armor. Provides complete mechanical protection, as well as time delay in event of flash fire.

TYPE PA

TYPE PAT

TYPE PT



TYPE XPT-U

TYPE XPT-F

TYPE XPT-FA

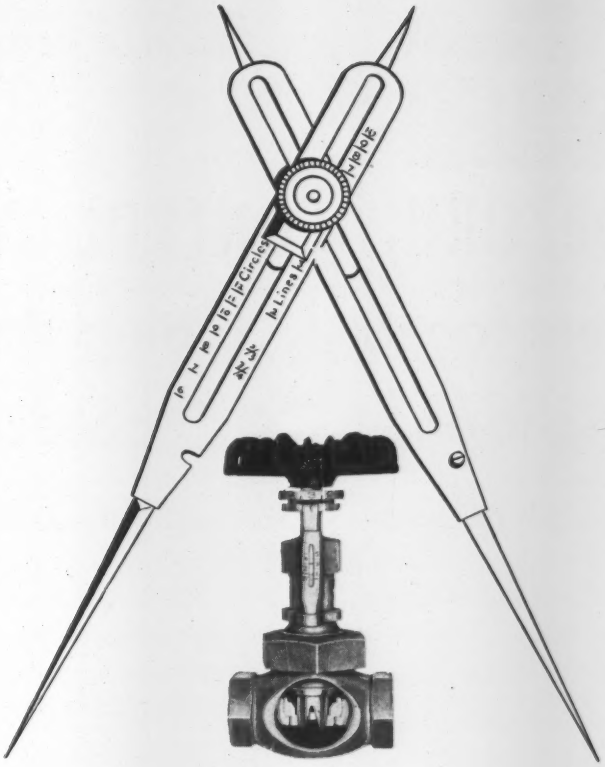
Write for complete information on these types, as well as types employing copper or aluminum tubing.

Ask for bulletin No. 458-A

CRESCENT INSULATED WIRE & CABLE CO., INC.

TRENTON, NEW JERSEY

CIRCLE 51 ON READER-SERVICE CARD



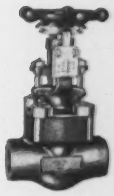
PROPORTIONER

controls flow to save for you

The V-port disc in all Hancock "Flocontrol" Valves insures proportional flow throughout the entire lift of the stem. They are valves that help you achieve uniform product quality through closer control, save steam and fuel on process work, and cut maintenance costs.

"3 in 1" valve design combines variable orifice with shut-off and micrometer dial and pointer. The valve opening can be set within 1/10 turn of the handwheel —you can duplicate all settings easily, instantly. No shut-off valve required—flow is in a straight line, with separate shut-off seating surface located away from the V-ports.

Hancock "Flocontrol" Valves are available in Bronze and Steel to meet the most demanding services. Ask your industrial supply distributor for details.



Hancock "Flocontrol" valves assure positive pinpoint control—eliminate all guesswork.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

H1-58

HANCOCK "FLOCONTROL" VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Watertown, Massachusetts

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 52 ON READER-SERVICE CARD

LEAKAGE? NONE !

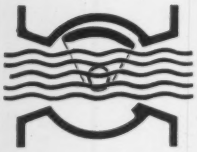
with DeZURIK CONTROL VALVES

This resilient-faced plug shuts dead-tight on gases, liquids, slurries every time!

Resilient seating is standard on a DeZurik Valve—not an added expense "extra". Actually this resilient seating costs LESS than metal to metal seating; lapping is not necessary. Plug life—even on slurries—is almost unlimited. The facing is solidly bonded to a metal core; there is no continual flexing.

CAPACITY? HIGH !

with DeZURIK CONTROL VALVES

Straight-thru flow port area reduce  and liberal turbulence and erosion, permit higher capacity - size for size - than ordinary control valves!

Again, there's a saving in cost! A DeZurik Control Valve a size or two smaller and at a lower price, will often handle the same service handled by a higher priced, larger size ordinary control valve. And it will handle the service with less turbulence . . . . less erosion . . . . and a resultant longer valve life!

Find out more about the unusual advantages of DeZurik Control Valves. Ask the DeZurik representative in your area, or write for Bulletin 150.

DeZURIK CORPORATION
SARTELL, MINNESOTA

CIRCLE 53 ON READER-SERVICE CARD

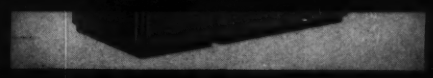
S-C 4020 HIGH-SPEED MICROFILM PRINTERS

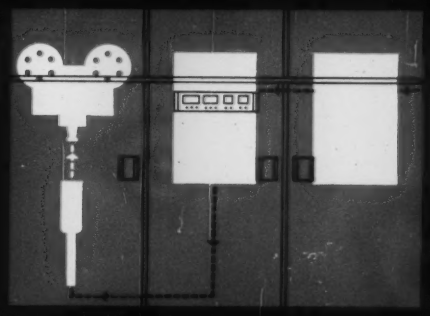
Capable of printing characters and plotting points at the rate of 15,000 per second, the S-C 4020 is equally adaptable to commercial and scientific applications where high-speed microfilming is required. This versatile new printer is compatible with most high-speed data processing systems used throughout business, government and industry . . . and is capable of both on-line and off-line cperation. The S-C 4020 has resulted from experience gained by Stromberg-Carlson in the development, manufacture and field testing of other microfilm printers in the S-C 4000 Series, including the S-C 4000, custom-developed for use with the Livermore Automatic Research Computer (LARC), and the S-C 4010, now used in conjunction with the Naval Ordnance Research Calculator (NORC).

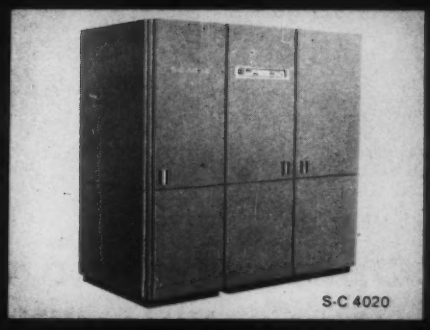
Send for complete information concerning the S-C 4020 High-Speed Microfilm Printer. Ask for Bulletin 6-(. Write today: Stromberg-Carlson - San Diego, 1895 Hancock Street, San Diego 12, California.

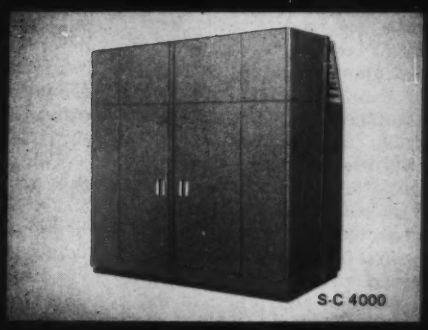
GENERAL DYNAMICS
STROMBERG-CARLSON DIVISION

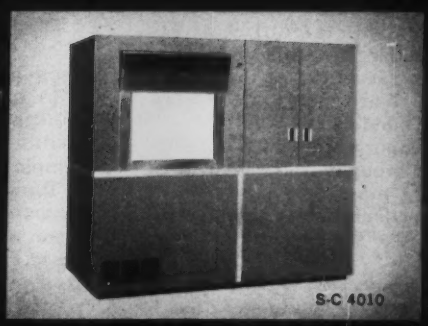
CIRCLE 54 ON READER-SERVICE CARD

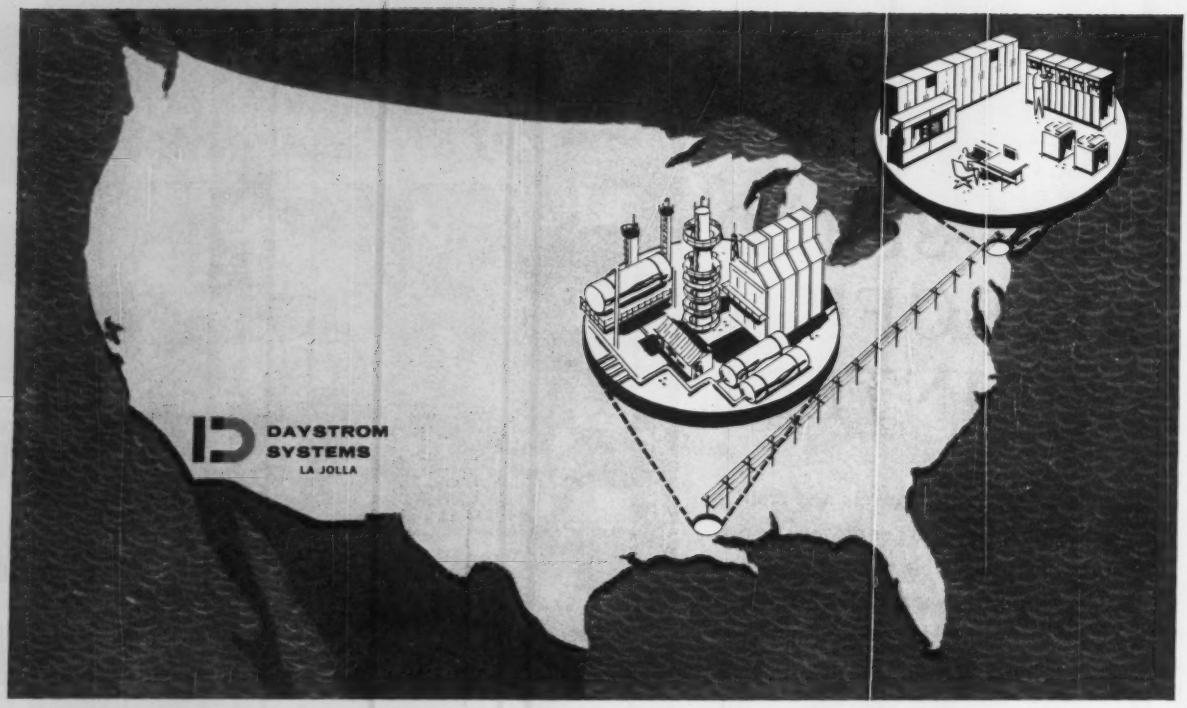












Now...in addition to on-line computer systems

Operating and test data reduction via telephone link utilizing any computer facility

The new Daystrom TPR Scanning System represents a revolutionary approach with vast implications where there are requirements for immediate or continuous computer analysis of plant operating or test data. The availability of this new tool will influence industry's plans in a number of important areas, which include process studies, experimental test work in the military and nuclear areas, and testing for performance guarantees.

For the first time, the TPR (tape programmed raw) data scanner makes it possible and practical to link a test or operational plant facility directly to any computer in the country for instant computation of data. This is made possible by the utilization of standard telephone communication services, and permits stationing of all engineering and computer programming personnel at the project site, where all phases of the work may be handled.

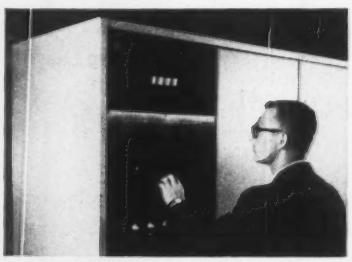
The importance of this development is brought into sharp focus by the almost non-existence of computer facilities at actual plant or test sites. The utilization of telephone circuits completely circumvents this problem since it makes little difference whether the computer facility to be used is located in an adjoining building, company headquarters or at a rental facility. Distance represents no problem other than nominal telephone service charges.

Telephone communication of this type is a practical reality in the business machine field and is being used every day by leading companies for inventory control, accounting and other purposes. The Daystrom TPR Data Scanner is the first system that has been specifically designed to handle the problems involved in gathering large amounts of analog data peculiar to plant and test facility operation.

The TPR Data Scanner's feature of tape programming provides unlimited flexibility. This permits unrestricted application of the equipment to various types of facilities even though they may be completely different in nature.

Typical of the unequalled performance specifications are 0.1% accuracy at the 99% confidence level, together with extremely high signal to noise ratio at scanning rates up to 40 variables per second. 100% solid state circuitry and full parity checking are incorporated. Input channels may be as few as 100 or as many as 6000.

For further information, write or telephone Daystrom Systems, Dept. A-127, Miramar Road, La Jolla, Calif. GLencourt 4-0421.

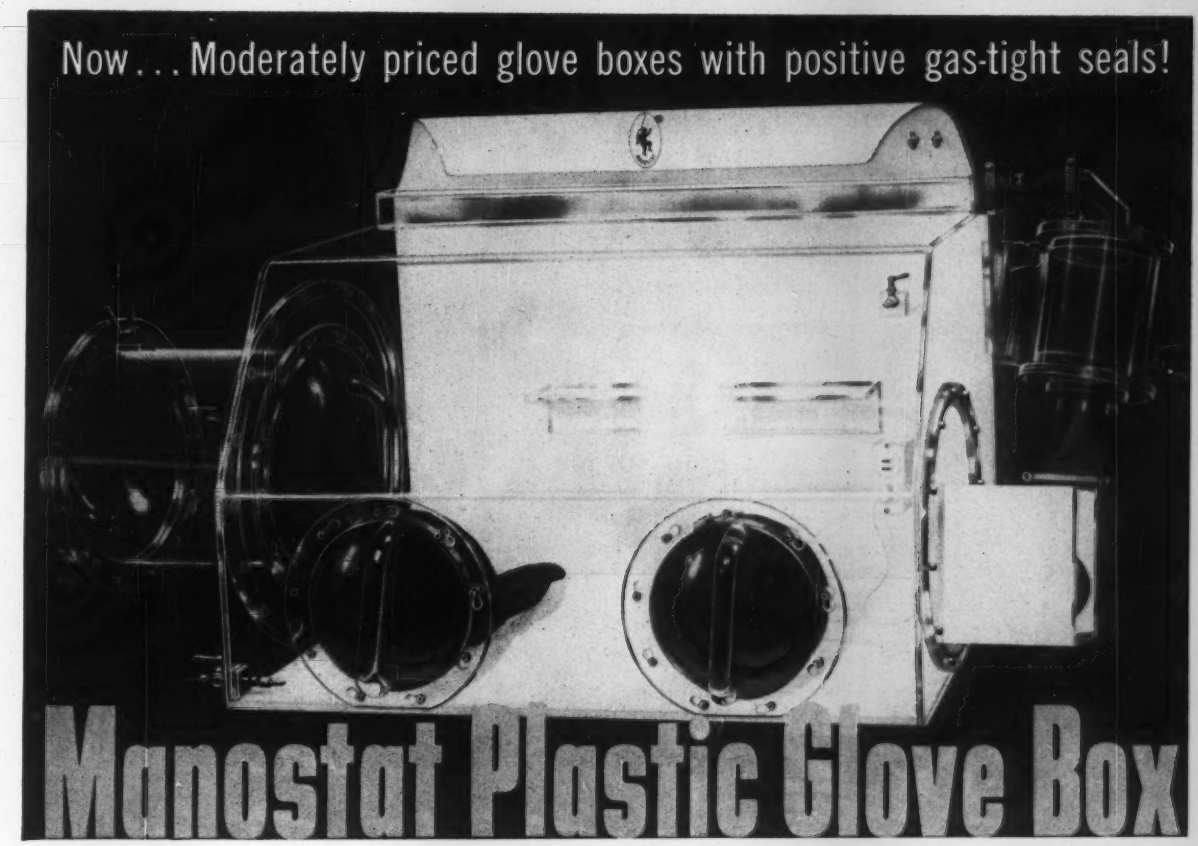


Typical 2000 point system delivered to a major nuclear propulsion test facility.

DAYSTROM SYSTEMS
DIVISION OF DAYSTROM, INC.
Reliable computer control systems

CIRCLE 55 ON READER-SERVICE CARD

Now... Moderately priced glove boxes with positive gas-tight seals!



Manostat Plastic Glove Box

Manostat introduces Plastic Glove Boxes with true *one-piece* construction, achieved with a chemical weld. Despite their moderate price, these boxes are designed and constructed with such de-luxe features as positive "O" ring seals throughout, for leak-proof performance . . . and a full 18" diameter side entry, for maximum convenience. The ¼-inch thick Rohm & Haas Plexiglas 1-A is unaffected by most inorganic solutions, mineral and animal oils, low concentrations of alcohol, paraffinic and olefinic hydrocarbons, amines, alkyl monohalides, and esters containing more than ten carbon atoms.

FEATURES:

1. Positive "O" ring seals throughout.
2. Opaque white background for greater visibility.
3. Sealed interchangeable circulating and filter system.
4. Filter that may be removed and installed without disturbing system.
5. Interchangeable 12" diameter, 12" long air lock with covers.
6. Covers for gloves so that they may be changed without disturbing system.
7. Uniform distribution of flow from circulating system by means of graded manifold.
8. Internal removable shelf for storage.
9. Plastic diffuser on fluorescent light.
10. External switches for all controls.
11. S.S. toggle valves for quick adjustment and preconditioning of system, air lock and filter.

PRICE LIST:

T952 - - SIMPLE GLOVE BOX, ready use, with side cover plates and all other accessories, as shown. (Does not include air lock or circulating system.) **950.00**

T952D - - AIR LOCK GLOVE BOX, ready for use, with air lock and all accessories, as shown. (Does not include circulating system.) **1,150.00**

T952D10 - - CIRCULATING GLOVE BOX, ready for use, with circulating system and all accessories, as shown. (Does not include air lock.) **1,250.00**

T952D20 - - COMPLETE GLOVE BOX, ready for use, with air lock, circulating system, and all accessories, as shown. **1,495.00**

Write for Bulletin GB

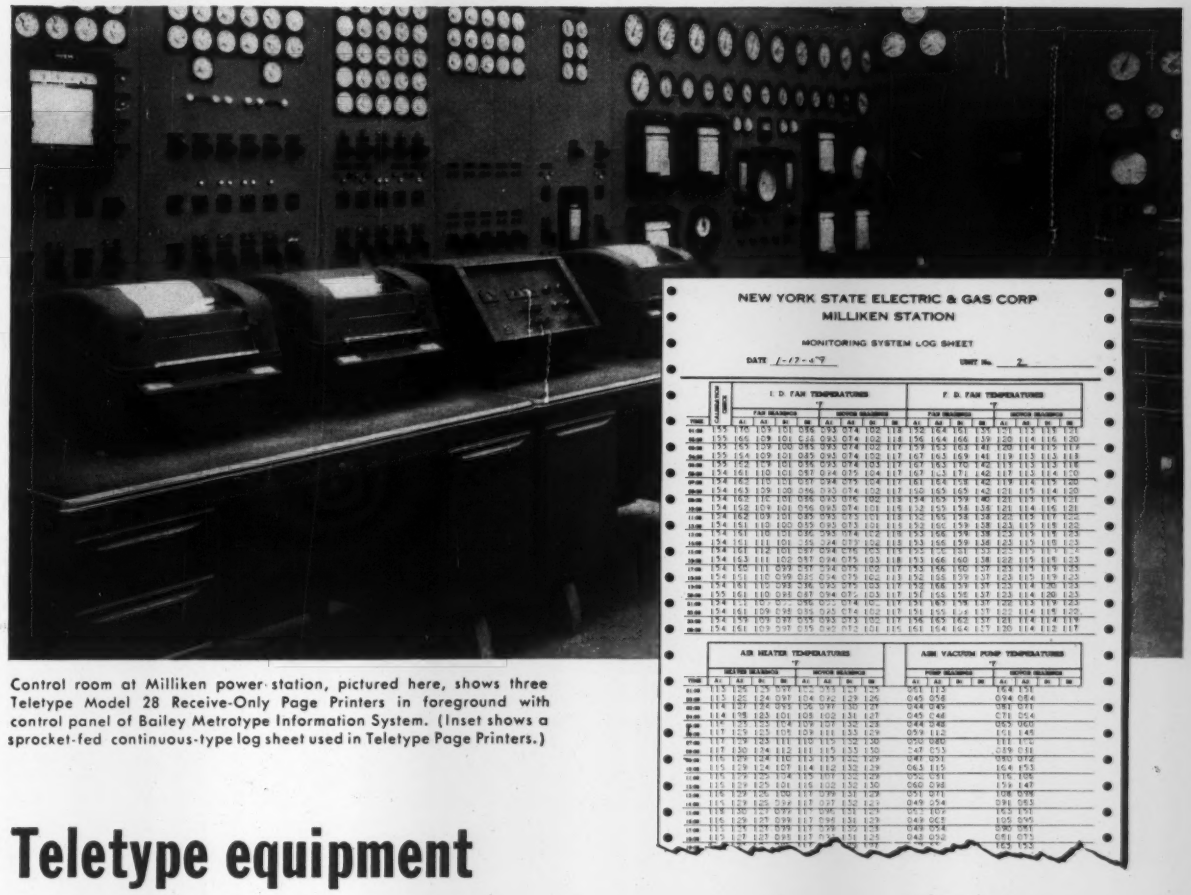
The EMIL GREINER Co. E&G®

20-26 N. MOORE STREET • DEPT. 230, N. Y. 13, N. Y.

CIRCLE 56 ON READER-SERVICE CARD

SWAGELOK
the Standard of Quality in Tube Fittings
SWAGELOK
Swagelok®
the name that stands apart from all others in the field . . . outstanding and unique in concept, craftsmanship and leakproof performance
CRAWFORD FITTING COMPANY, 884 East 140th ST. CLEVELAND 10, OHIO • CRAWFORD FITTINGS (CANADA) LTD., NIAGARA FALLS, CANADA

Automatic read-out . . .


NEW YORK STATE ELECTRIC & GAS CORP
MILLIKEN STATION
MONITORING SYSTEM LOG SHEET
I. D. FAN TEMPERATURES
F. D. FAN TEMPERATURES
AIR HEATER TEMPERATURES
AIR VACUUM PUMP TEMPERATURES

Control room at Milliken power station, pictured here, shows three Teletype Model 28 Receive-Only Page Printers in foreground with control panel of Bailey Metrotype Information System. (Inset shows a sprocket-fed continuous-type log sheet used in Teletype Page Printers.)

Teletype equipment monitors and records power station performance

New Model 28 Teletype Page Printers and Tape Punch equipment provide a continuous, dependable data processing facility for evaluating power station performance. This Teletype communication equipment is part of a Bailey Meter Company Metrotype® Information System installed recently at the Milliken power station of the New York State Electric & Gas Corporation, near Ithaca, New York.

This installation consists of two data systems:

1. A Monitoring System that continuously scans a total of 282 variables—temperatures of fan, motor and pump bearings; pressures of water and oil pumps, etc. Whenever readings exceed prescribed limits, system immediately reads and prints complete digital data of off-normal operation. In addition, complete readings are printed hourly.

2. A Performance System that scans 66 points once every hour, measures generator output, main steam flow, feedwater flow, temperatures, etc. All factors required to evaluate the station's performance are logged on the Teletype Printers. A Teletype Tape Punch also produces a perforated tape for IDP.

Robert Darke, Systems Division Manager, Bailey Meter, says, "Teletype equipment was chosen for this installation because of its flexibility and proven reliability. Design is simple and trouble-free, and the units are manufactured specifically for round-the-clock rather than intermittent service."

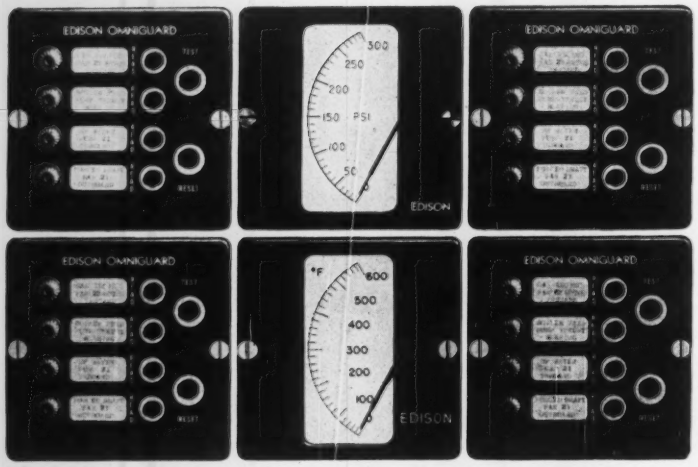
Teletype equipment will handle data for virtually any purpose in any industry. Signals may be serial or multi-wire. Signal medium may be local electrical circuit, telegraph or telephone circuit, or radio.

Why not find out how Teletype equipment can fit into your systems plan? Please write: Teletype Corporation, Dept. 23-K, 4100 Fullerton Ave., Chicago 39, Illinois.

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

CIRCLE 58 ON READER-SERVICE CARD

← CIRCLE 57 ON READER-SERVICE CARD


EDISON OMNIGUARD
300
250
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150 PSI
100
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EDISON
EDISON OMNIGUARD
EDISON OMNIGUARD
°F
600
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300
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100
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EDISON
EDISON OMNIGUARD

GUARD ALL CRITICAL PRESSURES AND TEMPERATURES WITH . . .

THOMAS A. EDISON LOW-COST, OMNIGUARD WARNING SYSTEM

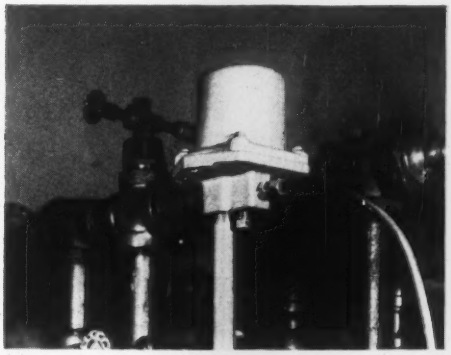
Here is a versatile, highly-reliable continuous warning and monitoring system. By simply pushing a button on this panel you obtain a reading of *key pressure* and *temperature* points throughout your plant. In addition, this system provides instantaneous warning when pressure or temperature deviates from pre-set limits.

PRESSURE With the Edison Omniguard system you can monitor gas, fluid or vapor pressure. Heart of the system is a rugged accurate pressure detector which converts pressure directly to electrical resistance—requires no milli-volt conversion—no amplifier. For pressures under 60 PSI a precision capsule is the sensing element. From 60 to 3000 PSI special bourdon tube elements are used.

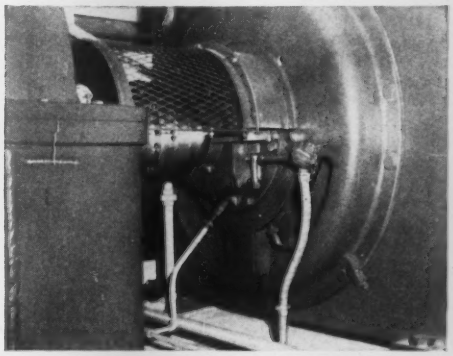
When pressure changes, resistance varies and this deviation is transmitted to the control panel. Units operate over ambient temperatures of 32° to 150°F. Control panels are available with a wide variety of scales and are equipped with both normally open and normally closed alarm contacts to operate any type of auxiliary device or to automatically shut down machinery or process.

TEMPERATURE Edison Omniguard also provides reliable protection from overheating. You can monitor the temperature of bearings, gases and liquids in critical equipments or processes. Reliable Edison Resistance Temperature Detectors have no moving parts and give instantaneous warning when limits are exceeded. Unlike other systems which only scan, Omniguard is continuously monitoring. You can obtain exact readings of temperatures in all parts of your plant from one central control panel.

For greater flexibility and reliability each detector circuit is completely independent. If one circuit is damaged, all other circuits remain "on guard." When changes or additions are required they can be accomplished quickly and easily.



Compact, reliable Resistance Pressure Detector transmits changes in pressure to central control panel.

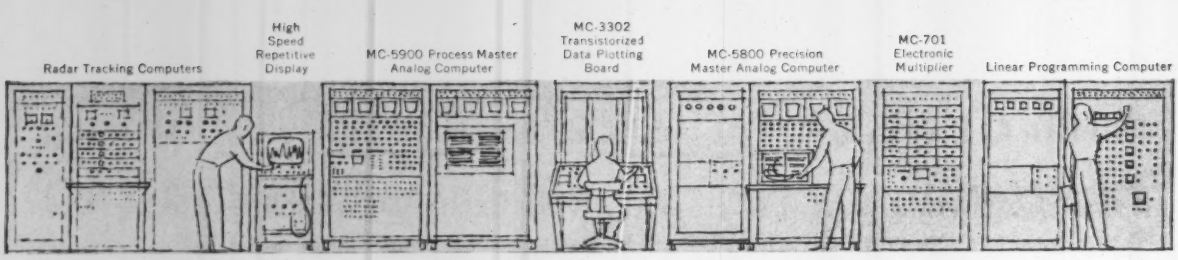


Rugged, accurate Resistance Temperature Detector guards against overheating of this motor bearing.

Thomas A. Edison Industries
INSTRUMENT DIVISION
24 LAKESIDE AVENUE, WEST ORANGE, N. J.

McGRAW EDISON

CIRCLE 59 ON READER-SERVICE CARD


Radar Tracking Computers
High Speed Repetitive Display
MC-5900 Process Master Analog Computer
MC-3302 Transistorized Data Plotting Board
MC-5800 Precision Master Analog Computer
MC-701 Electronic Multiplier
Linear Programming Computer

Some people can prove man and mouse are identical

It's all according to the points of similarity you choose. *Differences* are what really *prove* the superiority of man over mouse. Computers have differences, too. In fact, it's in these differences that the CSI-designed MC-5800 obsoletes every other Analog Computer. The best proof lies in

cold
hard
Specifications

- Exclusive dynamic memory makes automatic iterative solution of statistical or optimization problems a reality.
- Stable amplifier operation over the entire feed-back range from zero to infinity.
- Lowest amplifier grid-current $<10^{-9}$ ampere.
- Amplifiers provide lowest noise level output—less than one millivolt at unity gain.
- Amplifier frequency response—flat to 10,000 cps and only 3 db down at 28 kc.
- Real-time precision @ speeds to 60 solutions/sec.
- Exclusive electronic generators of the function of two-or-more variables may be programmed at patch-board in same time required for setup of single-variable generators.
- Will program 134 amplifiers, 30 electronic multipliers, 18 diode function generators, 2 time-delay generators, 8 relay amplifiers, and 6 servos from one 2128-hole patchboard.
- Highest performance electronic multiplier—flat to 10,000 cps and only 3 db down at 20 kc.
- Dynamic memory + high-speed quick-reset rep-op provide practical approach to solution of simultaneous partial differential equations.
- Dynamic memory with time-base accuracy of ± 10 μsec provides automatic parameter searching by iteration—an exclusive capability.
- Solution of problems with up to 15 amplifiers in closed loops.
- Plug-in dynamic components ease maintenance.
- Lowest computer cross-talk—rejection greater than 2,000 to 1.
- Selection of real-time, expanded-time or high-speed compressed-time without reprogramming.
- Passive networks stabilized at $<$ 1°C above room ambient—no oven required.
- EVERY SPECIFICATION IS GUARANTEED TO BE TRUE PERFORMANCE STANDARD—IN SUSTAINED OPERATION.
- Only diode function generators utilizing resistors, potentiometers, and diodes of equal quality to those in computing networks.
- Only diode function generators with individual hi-lo gain positions for *each* segment.
- Lowest function generator drift $<$ 5 mv/8 hrs.
- Lowest servo step-function overshoot—less than 1%.
- DC tachometer feedback on all servos.
- Complete control of all amplifiers, multipliers, dividers, and non-linear equipment at patchboard.
- Exclusive equipment-door packaging for free access and quick maintenance *without* shutdown.
- Insulated patchboard prevents costly shorting accidents.
- Power supplies eliminated from console—lowest, most stable operating temperatures—rise $<$ 3°C.
- Field expandable without mechanical rework or rewiring.

There are many more differences (over a hundred, in fact). Before you buy or lease your next analog computer, compare them all... and we think you'll agree with us when we say: The MC-5800 obsoletes every other analog computer made.

Computer Systems, Inc.—designers and manufacturers of the *highest* precision analog computers and computer accessories.

MAN IS A MOUSE

COMPUTER SYSTEMS, INC., 611 BROADWAY, NEW YORK 12, N. Y. • SP 7-4016
A Schlumberger Subsidiary • formerly Mid-Century Instrumatic Corp.

CIRCLE 60 ON READER-SERVICE CARD

CIRCLE 61 ON READER-SERVICE CARD ⟶

Here you see a specially trained North American crew carefully loading a Burroughs computer. Professional crews such as these move electronic computers valued as high as three-quarters of a million dollars each.

Why Burroughs uses North American Van Lines for shipping electronic computers

"Because of North American's superior handling and delivery service, they are awarded a large portion of all shipments of our expensive and delicate electronic computers," asserts W. A. Reed, Traffic Manager, ElectroData Division, Burroughs Corporation.

He goes on to say, "North American's custom floor-to-floor delivery service is especially important in transporting items of this size and weight. Their crews have the necessary equipment and know-how to place the computers exactly where our customers desire. And by using North American's services we can ship our computers almost 100% assembled."

This is just one more example of how North American Van Lines' Kid-Glove handling and complete service all the way eliminates the many problems involved in shipping High Value Products.

Call your local North American agent and get the facts first hand. He'll be glad to talk with you about *your* product moving problems without obligation.

See "Championship Bridge" on TV

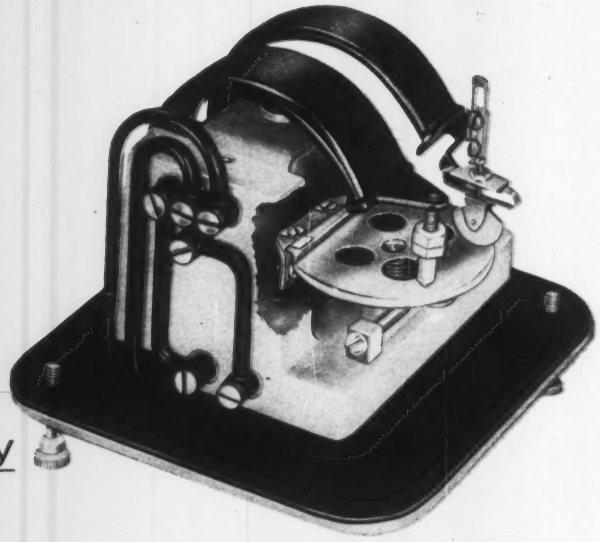
Watch North American's exciting new television show featuring Charles Goren and Alex Dreier every Sunday afternoon on ABC-TV—starting Oct. 18.

North American
WORLD-WIDE MOVING
LAND · SEA · AIR

Experts in moving Household Goods, Displays, New Products and High Value Products.

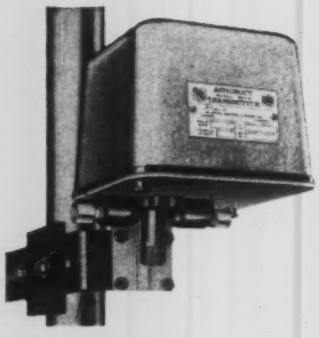
NORTH AMERICAN VAN LINES, Inc. / World Headquarters / Dept. 18-5 / Fort Wayne, Indiana

In Canada, North American Van Lines Canada, Ltd., Pickering, Ontario . . . In Europe, North American Van Lines, Europe, GMBH, Mannheim, Germany



NEW high sensitivity ASHCROFT PNEUMATIC TRANSMITTERS

lower costs...reduce maintenance ...provide tighter control



Ashcroft Non-Indicating Pneumatic Transmitters are made in pressure and temperature types, each in regular and short span. Operation is on low-pressure air: output range, 3-15 psi or 3-27 psi.

These new transmitters are designed around (1) a powerful, efficient relay with sensitivity high enough to operate controllers, and (2) a simple, dual Bourdon tube motion-balance system. High sensitivity permits the use of narrowest proportional band settings on controllers and allows instant controller response to deviations from set point. With a shorter transmission lag, automatic corrective action starts before the deviation becomes critical.

In manual control systems, these new Ashcroft Transmitters (teamed with suitable receivers) make it practical to operate boilers at the most efficient level. In wet processing operations, fractionating columns yield a purer product. Highly suppressed Ashcroft Short Span Transmitters are so sensitive they can "judge" entire control loops and detect any errors in the system.

Basically a 6″ cube, lighter than most 8½″ pressure gauges, these climate-proof Ashcroft Transmitters are simple to install in cramped locations, are most readily accessible for adjusting or service. Calibration is extremely easy, with linearity checking entirely eliminated. Most parts in all types in the line are interchangeable. Ask your nearby Ashcroft Gauge Distributor about the lower initial costs and other savings that follow when you install Ashcroft Non-Indicating Pneumatic Transmitters. Send for Bulletin 361.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

ASHCROFT PNEUMATIC TRANSMITTERS

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CIRCLE 62 ON READER-SERVICE CARD

14th ISA Show

editorial

THE 14TH ANNUAL ISA Conference and Exhibit was held the week of Sept. 21, in Chicago. An exhibit reflects the state of the art as practiced in the field. The 1959 exhibit showed that the year was one of consolidation and refinement, with none of the "breakthroughs" (computer control, electronic controllers, loggers, etc.) characteristic of former years. Yet many significant new instruments and complete new lines of instruments deserve special mention:

1. The Telechrome Memotizer with 2 code drums offers both analog-to-digital conversion plus storage accumulation which opens up many new applications.

2. The Hankison Refrigifilter uses a compressor plus heat exchanger to obtain low-dew-point instrument air at unprecedented economies.

3. Industrial Process Engineers introduced a complete new line of process instrumentation that accepts any a-c or d-c signal, and includes controllers plus motor-operated valves as final operators.

4. Hagan new Series 2000 Kybernetes loggers feature solid-state construction; also new Hagan solid-state PowrMag analog-computer control elements feature patch-board interconnection.

5. Bailey Metrotype loggers also feature solid-state electronics. Trend to solid-state electronics was evident also in Baily electric control system. New Pyrotron radiation pyrometer with bolometer element also attracted much attention.

6. National Cash Register "Photochromism" recording technique is of special significance to field of recording; it uses dyes which can be changed between two color states by ultraviolet light—"optical switching." The NCR magnetic-rod storage elements also are of special interest to the computing field.

7. Sanborn x-y optical recorder has response to 100 cps; a motor-driven chart viewer was also introduced by Sanborn.

8. Gerber introduced a complete line of chart viewers plus scaling and linearizing accessories; also new x-y plotter.

9. Librascope x-y plotter features compactness, flexibility and speed.

10. Research, Inc., introduced the DataTrak function generator in which a probe follows the center of electrostatic field produced by two pencilled lines on a chart.

11. Both mass and magnetic flowmeters received great attention, particularly the GE massflowmeter, and the F&P and Foxboro magnetic flowmeters.

12. Foxboro introduced a line of solid-state computing elements (arithmetic); also new panel and console concepts.

13. Assembly Products' new CRMR (continuous-reading meter-relay) controls and reads independently.

14. Bristol introduced both new low-range infrared instrumentation and a new multipoint Dynamaster that can select any or all of up to 24 points.

The number of computers exhibited, both analog and digital, was less than in preceding years—but the emphasis in the technical sessions was on computers, particularly control computers; nearly ⅓ of all papers were on the subject of computers.

Computer Manufacturers On A Limb

One computer meeting held at the show started off with a deceptively simple idea which has mushroomed into an uncomfortable position for many computer manufacturers. The meeting was a follow-up meeting to one held by the AIEE Computer Systems Subcommittee at Boulder, Colo., May 20-22. Over 50 persons attended this followup meeting, held at the Panelit Cafeteria on the Friday evening after the ISA meeting closed. The 50 represented computer manufacturers and process users interested in computer control.

At the Boulder meeting, Ted Williams of Monsanto had offered to prepare a typical chemical problem for computer solution; the several computer manufacturers present offered to solve the problem. In this way both the differences between types and makes of computers could be evaluated.

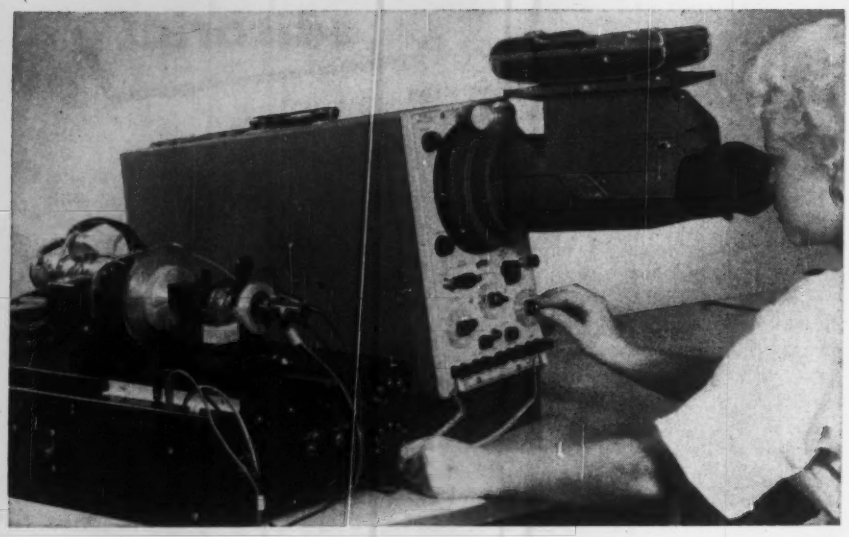
The idea appeared sound, and Williams developed a problem wherein a feed stream enters a stirred-tank reactor, then flows into a reactor cooler heat exchanger, then to a decanter and, finally, to a distillation column. Mr. Williams was kind enough to include all pertinent transfer characteristics.

Only later did the hidden dangers become apparent to the computer manufacturers, who have perhaps become accustomed to rushing into situations where angels tread carefully. First of all, the degree of satisfaction of the solution depends on the amount of engineering time spent on the problem; from $10,000 to $20,000 is a minimum. Second, it soon became apparent that the preliminary solutions do not prove economies (prices would have to be mentioned or else the problem becomes academic). Thirdly, some firms can solve the problem only by revealing developmental techniques or computers still under wraps.

None of this background will appear in the rash of sensational news that will be headlined in the technical press under the heading of "Computer Manufacturers Solve Process Problem." However, as of this moment, several computer manufacturers feel uncomfortably far out on a slender and expensive limb.

The problem is available to any computer manufacturer interested in the solution. All papers on the problem which are submitted to the AIEE Computer Systems subcommittee before Nov. 27 will be preprinted.

The solutions are scheduled for presentation at the Winter General Meeting, Control Computer Session, American Institute of Electrical Engineers, New York, Jan. 31-Feb. 5. We will keep our readers informed.



Use of oscilloscope-camera unit to record potentiometer characteristics. Servo-driven linearity tester compares master potentiometer with unit under test. (Courtesy Spectrol Electronics Corp.)

Oscilloscope - Camera Recorders

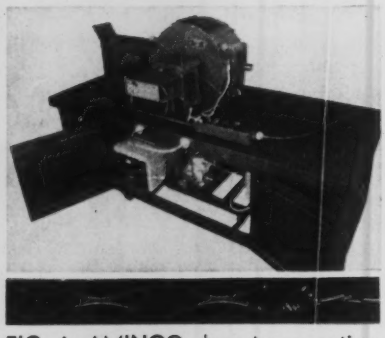


FIG. 1. AMINCO drum-type continuous-motion oscilloscope-recording systems. B shows typical record.

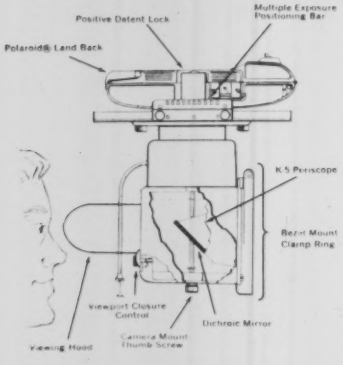


FIG. 2A. BEATTIE periscope assembly.

THE CATHODE-RAY-TUBE and camera recorder is the most popular technique for recording of signals above 5000 cps; it is useful to frequencies above 1000 megacycles. Available equipment includes units for single-frame exposure, continuous-film motion, or cine-film motion. Accessories include special lenses and high-speed films (with exposure index of 3000). This survey completes our previous discussion of galvanometer, light-beam, potentiometer, operations, pneumatic, and multi-styli recorders.

American Instrument Co.

In the Aminco high-speed oscillograph camera (Fig. 1) the film is on a drum. As it moves at the desired speed in readiness for recording, there is no need of synchronizing film movement to signal display (but shutter does need synchronized). Recordings are made by focusing the desired image on an endless strip of photo-sensitive material. The shutter can be opened at any time and closed when any preselected length of record has been taken.

The linear speed of the film is continuously variable from zero to 1735″/sec. A record 976″ (81′) long can be made on the strip of film. Lateral motion of the film drum along its axis of rotation takes place automatically whenever the shutter is open, producing a helical record. This prevents overlapping exposures. Time calibration marks (1-ms) are placed on the film adjacent to the record simultaneously and automatically to an accuracy of one per million.

Fig. 1B shows a record made of a 425-kc carrier, modulated approximately 70% by 500-cycle tone, and interrupted by a motor-driven switch 100 times per second. Drum speed was approximately 70 rpm (40% of maximum speed); timing mark interval is 1/500 second. Note the chatter of the switch contacts when they were opened. With a brighter screen on the oscilloscope, or with a spot of greater intensity, a higher drum speed can be used to expand the time axis. It is possible to resolve signals up to 80 kc or more; transients from 1 sec to 12 microsec can be recorded. A 5″ oscilloscope with a P-11 phosphor should be used for best results.

Beattie-Coleman

The Beattie line comprises a periscope unit with various camera attachments; also special "Radarscopes," cameras for reading the output of an IBM 704, and a "Fluorotron" for mass x-ray tests.

The Beattie Oscillotron Model K-5 recorder, provides a group of interchangeable components for recording with single-frame, continuous-motion, and Polaroid-Land cameras.

The basic component is the periscope assembly (Fig. 2A), which attaches to the oscilloscope with a split clamp ring. A hooded view port is provided in the front of the periscope assembly. The CRT image can be viewed directly through a dichroic mirror, permitting binocular vision.

The following cameras can be mounted on the periscope assembly:

1. Beattie 60-second camera with a Polaroid-Land camera back. Up to 10 traces can be recorded on a single frame, up to 80 traces on a single roll. Standard camera is equipped with a Wollensak Raptar f/1.9 lens with #3 Alphax shutter (1 sec to 1/100th second, time and bulb), and ground-glass focusing panel. A small Polaroid-Land camera back, useful for economical 60-second CRT recording uses the smaller Polaroid-Land film. Minification is approximately 2:1

2. 35-mm Oscillotron camera, comprising a modified Beattie Varitron and featuring an automatic electric 35-mm magazine that accepts up to 100′ of film. The camera is actuated electrically on demand or through an intervalometer, and can be triggered by the event being recorded. Remote control and simultaneous recording of displays on a number of oscilloscopes is accomplished easily. Standard equipment includes 38-mm f/1.9 Wollensak lens in focusing mount, 1/50-sec tripping or holding shutter, and ground-glass focusing panel.

3. A continuous-motion film magazine that records variable-intensity or vertically-variable-position CRT spots. The film is advanced continuously across an open aperture at discrete lineal speeds of 1/16, 1/8, 1/4, 1/2, 1, 2, 4 and 8 inches/sec by interchangeable external gears. Available in 35- and 70-mm models, 115-volt 50-60-cycle ac or 28-volt dc.

The KD-5 Oscillotron system (Fig. 2B) permits simultaneous recording of CRT phenomena and appropriate identifying data.

Beattie also has a new direct-view Oscillotron (Fig. 2C) that permits the user to view the cathode-ray tube in a direct line of sight while recording.

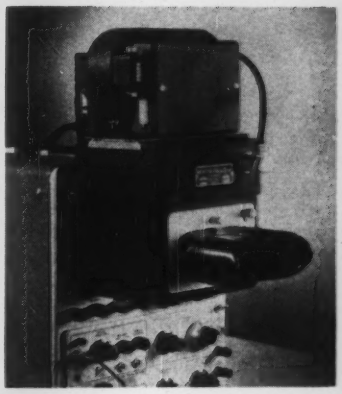


FIG. 2B. BEATTIE KD-5 Oscillotron with continuous-motion film magazine mounted for simultaneous recording of CRT phenomena and appropriate identifying data.

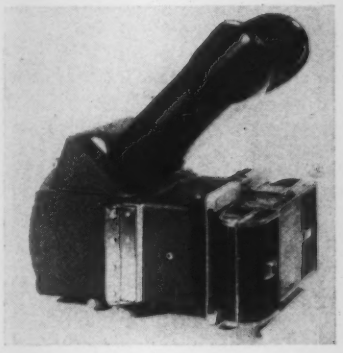


FIG. 2C. DIRECT VIEW Oscillotron.

FIG. 3A. B & W Model 224 drum camera.

Beckman & Whitley

Beckman & Whitley makes two continuous-writing drum cameras for oscilloscope trace recording. Model 224 (Fig. 3A) provides a continuous streak image on 35-mm film approximately 50″ long. Also approximately 70 pictures 17 x 25 mm when used with the Model 189 framing camera. Sweep rate is 120 meters per sec. Time resolution is 1.2×10^{-6} sec at f/2.8.

Model 307 (Fig. 3B) provides a continuous streak image on 35-mm film approximately 15″ long. Sweep

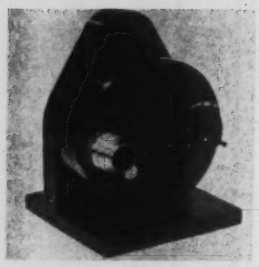
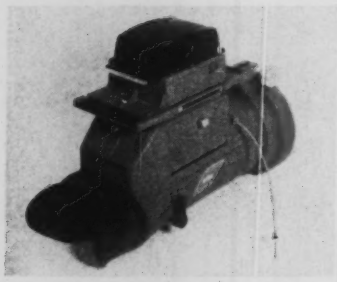
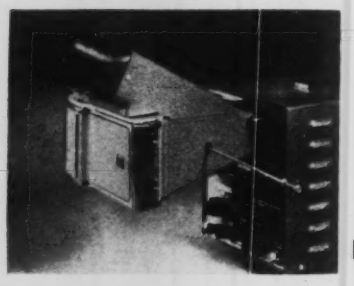


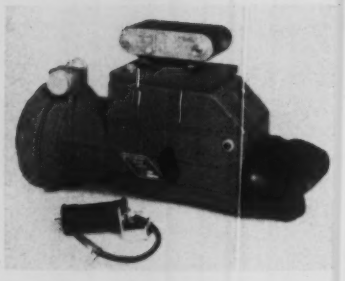
FIG. 3B. B & W Model 307 streak recorder.



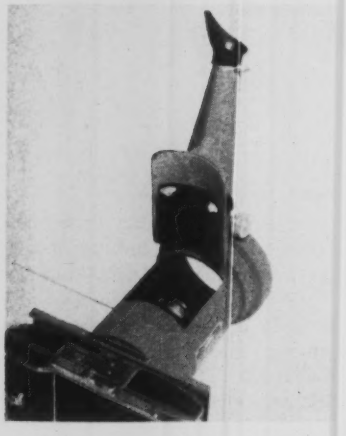
A



B



C



D

FIG. 4. DUMONT Type 299 for multiple, separate exposures; B shows Type 399 direct-view; C shows Type 352 camera and scope that can be triggered simultaneously and automatically; D shows Type 353 direct-view with 1 to 1 object-to-image ratio.

rate is 300 meters per sec. Time resolution is 5×10^{-7} sec at f/2.0. Auxiliary equipment includes an automatic film loading and unloading casette, and a drum speed indicator.

DuMont

DuMont Oscilloscope Recording Cameras for 3″ and 5″ oscilloscopes include single-frame, continuous motion or automatic frame-advance units, on (1) standard film emulsions, (2) roll, cut or strip film, or (3) transparent or opaque Polaroid film.

The Type 299 (Fig. 4, A) uses a Graflex camera with a variety of backs available for use with many styles of conventional film, 120 roll or cut. It is useful in general-purpose recording from 5″ oscilloscopes.

The Type 302 uses a Polaroid camera back and is interchangeable with the Type 299. In both, a data card provides picture identification. A dichroic beam-splitter permits viewing of waveform, while recording, without danger of fogging film, and multiple, separate exposures per frame are possible. Three detent stops position the back for three equally-spaced exposures, while a scale and pointer arrangement assists in positioning the back accurately for more than three exposures per frame. Image reduction is 2¼:1.

The Type 321-A camera provides for recording any 5″ oscilloscope display, either through continuous moving-film or single-frame exposures. Facilities for remote control are provided. An f/1.5, 51-mm seven-element Wollensak coated lens ensures high-resolution images, without distortion, regardless of aperture setting. An f/2.8 lens also is available. The film transport system holds up to 400′ of film and provides 16 selectable film speeds ranging from 0.8 to 3600″/min for full-length recordings. Two additional speeds of 5400 and 10,800″/min are available for short-length recordings. Timing markers are developed by a flashing argon glow lamp behind a small aperture in contact with the film.

The Type 339 Polaroid camera (Fig. 4, B) provides for recording from 3″ oscilloscopes. Features include f/2.8, 50-mm lens, Alphax shutter, binocular viewing, quick connect/disconnect bezel fixtures.

The Type 352 (Fig. 4, C) is a high-speed, automatic camera for photographing from 5″ oscilloscopes on 35-mm film. It is capable of advancing film frames rapidly and automatically. With the shutter solenoid supplied it can be operated remotely. This camera is fitted with a spring-wound automatic film advance capable of transporting from one to 17 frames of film with one winding. It can take a sequence of pictures automatically as long as the shutter release is held down—within the limits of the spring motor. An accessory spring booster motor extends the available automatic film advance up to 50 frames with one winding. The rate at which sequence exposures can be made depends on the shutter setting; for example, at the 1/500-second setting, 6 photographs may be made in one second. In general, the maximum writing rate capable of being photographed is about 75″/usec using a P11 screen on a CRT operating at 9 kv.

The Type 353 Polaroid 1:1 camera (Fig. 4, D) produces image-sized, (2⅞″ x 3¾″) non-reversed records

of traces from any standard 5″ oscilloscope. A sliding detent back and rotatable barrel also permit multiple exposures per frame on either the long or short film dimension. Monocular viewing permits direct viewing of the trace simultaneous with recording without danger of fogging the film under normal lighting conditions. A light-tight access door may be left open to allow direct viewing of traces during set-up procedures. Either transparent Polaroid film (Type 46L) or direct print Polaroid film (Type 42 or 44) in eight-exposure rolls can be used.

Electro-Medical Laboratory

The Electro-Medical oscilloscope camera is shown in Fig. 5 with the Garceau Electromyograph.

The camera uses standard 100′ reels of 35-mm film. There is a simple manual shutter, no iris, and an f/2.1 coated lens, which can be focused to get full film coverage from CR tubes 2″ to 21″ in diameter. Film speed in standard model is adjustable from about 1 to 10″/sec; film motion is continuous.

No hood is required for recording in subdued daylight or incandescent light with plain (not panchromatic) film and P11 phospor tube. 10-kc traces can be recorded.

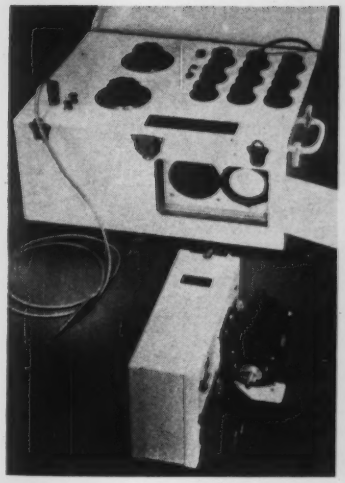


FIG. 5. ELECTRO-MEDICAL camera can be positioned to view various-sized CRT screens.

Electronic Tube Corp.

The ETC SM-100 camera is designed to fit all standard 5″ bezels. It records on either 35-mm film or paper (perforated or unperforated) at a rate of from ½″ to 12,000″/min. Film capacity is 400′ or 1000′. A binocular viewer allows continuous viewing in subdued light during recording. The camera mounts in either a horizontal or vertical position and can be used with sloping-face console-type scopes. Object-to-image ratio is 4.5:1; timing marks are provided, and data card can be illuminated.

ETC Model SM-200 (Fig. 6) uses the Polaroid-Land camera back, f/1.9 Wollensak lens and Alphax shutter in a special mounting for fast single-frame prints and slides.

Using Polaroid Type 42 film, the SM-200 can record traces running at a sweep speed of 1/10 microsecond per centimeter at a repetition rate of 10 cps. The new Polaroid film Type 47 will record even faster traces.

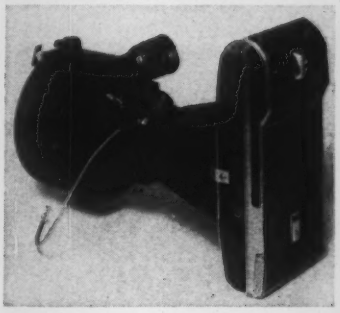


FIG. 6. ETC Model SM-200 Camera.

Fairchild Camera & Instrument

The Fairchild-Polaroid oscilloscope camera Model F-286 (Fig. 7) provides two exposures on each print through a 2-position quick-shift mechanism. Also, by shifting traces on the CR tube, multiple exposures can be placed on each half of the film. Camera is equipped with a 75-mm f/1.9 Wollensak Oscillo-Anastigmat lens and #3 Alphax shutter having speeds of 1 sec to 1/100 sec, "time" and "bulb." Image size is one-half of scope image. Model F-296 has same lens and shutter as Model F286 but provides 1:1 image ratio (single image on each frame).

Using the latest Polaroid film, traces with speeds up to 300 cm per microsecond can be recorded by either model. Also, traces with speed up to 8000 cm per microsecond can be recorded by pre-fogging the film.

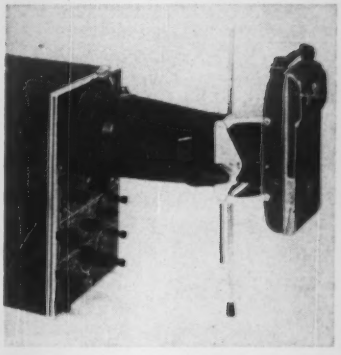


FIG. 7. FAIRCHILD-Polaroid Camera.

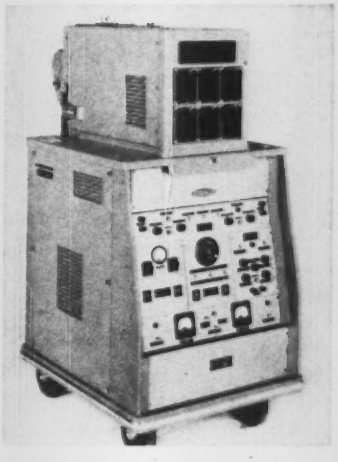


FIG. 8. HAMILTON SC-16B has six cathode-ray-tube units; records 200,000 cps.

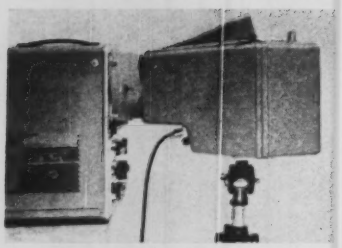


FIG. 9. H-H Type C6 camera.

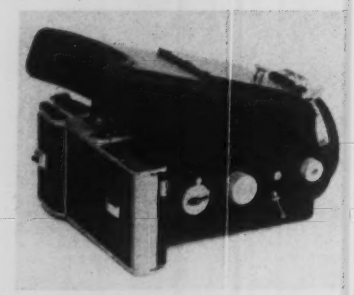
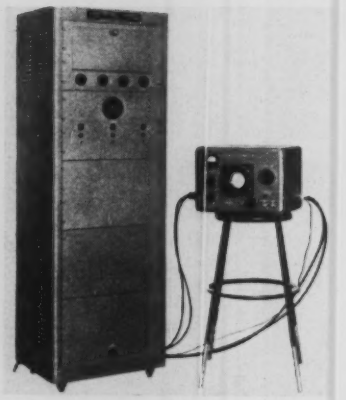


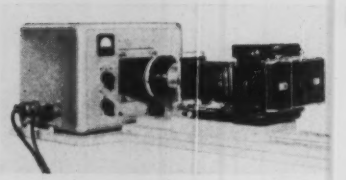
FIG. 10. HEWLETT-PACKARD Model 196A permits lateral positioning of lens.

FIG. 11. IBM 740 computer output device can display data points at a rate better than 7,000 per second.



A

FIG. 12. LIBRASCOPE Model C Image Converter Camera can photograph millimicrosecond transients.



B

Hamilton-Hathaway

Hathaway Instrument Division of Hamilton-Watch Co. offers the SC-16B cathode-ray multi-channel recording oscillograph for recording transient and periodic phenomena of high frequency (Fig. 8). Frequency range is 0 to 200,000 cps; writing speed is up to 5,000,000″/sec. Drum-type magazines permit chart speeds up to 6,000″/sec. Continuous-drive magazines use either recording paper or 35-mm film at speeds to 600″/sec.

Each of the six recording elements is a complete CRT and amplifier unit; interchangeable lens stages can present the 6 traces (or less) on 6″ or 35-mm chart.

The oscilloscope camera Type C6 (Fig. 9) is a portable, continuous-drive camera using commercially-available, 6″ photo-sensitive paper or film for recording signals on 5″ oscilloscopes. An adjustable-height tripod has a universal head that permits recording in either a horizontal or vertical position. In the vertical position, the sweep of the scope can be used to achieve high-speed writing rates. Two types of interchangeable gears afford low and high paper speed ranges. The mechanical sweep mode of operation uses the regular continuous action of the chart, while a second mode of operation is provided by the mechanical sweep combined with the internal sweep of the scope. Typical writing rates are up to 350,000″/sec on paper with a P5 tube surface.

Lens is 50 mm, f/1.8, 90-mm focal length. Image-to-object ratio is 1:1, ±10%. Record material is standard 6″-wide commercially-available photo-sensitive paper or film, 100′ standard-base length or 150′ thin-base length. Paper speeds are 5″ to 275″ per second with high-speed gears (continuously variable), ¼″ to 17″ per second with low-speed gears (continuously variable).

Hewlett-Packard

The Hewlett-Packard Model 196A oscilloscope camera (Fig. 10) has an object-to-image ratio of 1 to 0.9 to show full 10-cm graticule width. Lens adjustments are made through an access port while the camera is in position. A standard camera bellows simplifies multiple-exposure procedures. A knob moves the lens through 11 detented positions while the camera back remains fixed. Second knob shown is the development timer. A quick-connect clamp provides support.

International Business Machines

IBM's 740 CRT recorder (Fig. 11) is used with the 704 and 709 data processing system. The shape of a cam can be computed, and the shape, together with successive positions of the cam, can be displayed and photographed for a permanent record. The 740 also can be programmed to display alphabetic characters, geometric shapes, engineering symbols, graphs, etc.

The 740 contains a 7″ cathode-ray-tube characterized by a raster consisting of 1,024 positions for the ordinate (Y) deflection and 1,024 positions for the abscissa (X) deflection. The tube has a persistence of several microseconds and has unusually precise deflection characteristics. Its position stability is better

than 0.1% and a minimum error of 0.5% positional accuracy can be expected. A camera using commercially available 35-mm film is standard equipment. The camera is equipped with a removable film magazine having a capacity of 100′ of perforated 35-mm film. Film frame change is under calculator control and requires less than 50 microseconds to initiate.

Librascope

The Librascope Model C Image Converter Camera (Fig. 12) photographs transient phenomena in the millimicrosecond region. The camera, designed around an image converter tube, is electrostatically focused and deflected. Exposure times to 10 millimicroseconds are possible.

The event can trigger the camera within millimicroseconds. Exposure time is adjustable. Each frame is independently controlled and continuously variable. Exposure time is 0.05 to 1.0 microsecond; frame spacing is 0.5 to 50 microseconds; number of frames can be 1 to 5 as selected.

Display also can be recorded by Polaroid camera mounted on special housing using fast Polaroid film. The image-converter tube holds the signal long enough to reproduce the signal on the Polaroid film.

Vought

Vought Company offers a large line of photographic data recording devices for all film sizes with frame rates from pulse operation (time-lapse) to over 1000 frames per second.

The VDR-4B holds 100′ of film on daylight-loading reels and can be provided with basic cine′ rates of 8, 16, or 24 frames per sec. Pulse rate can be determined by operator up to a maximum of 10 frames per second. Other versions are the VDR-42B (Fig. 13) that holds 200′ and the VDR-44TM (external magazine).

Optional features available include, timing light, crosshair aperture reticles, fiducial marks, boresights, etc.

Special oscilloscope recorders include a high-speed streak unit which records deviations in the "X" axis against a recorded time base, and a slow-speed unit which permits time exposures as long as 15 minutes with sequencing for the next operation in less than one second. Beam splitters provide various percentages of reflection and transmission depending on customer requirements. All of the pulse data recorders (time-lapse recorders) can be used to record CRT data.

Wollensak

Wollensak's line of Fastax cameras include continuous-motion oscilloscope streak recorders, full-frame and split-frame cameras for various film sizes and speeds, and time-lapse cameras.

Continuous-motion cameras have 100′ to 400′ film capacity and can record streak images from 4-200′/sec.

Models WF-14 and WF-15 (Fig. 14) are 400′ combination motion-picture and oscillographic-streak cameras. Oscillographic streak range is from 4′ to 200′ per second. The WF-14 takes 350 to 9,000 pictures per second; the WF-15 takes 700 to 18,000 pictures per second.

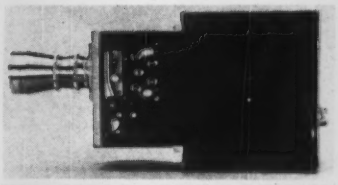


FIG. 13. VOUGHT VDR-42B with 200′ of film on daylight-loading spool.

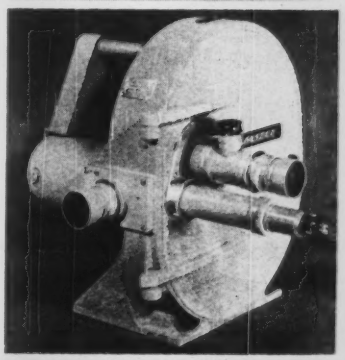


FIG. 14. WOLLENSAK combination motion picture and oscillographic camera.

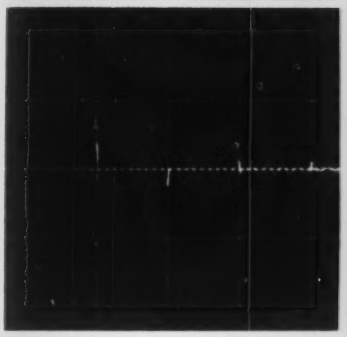


FIG. 15. RECORD of 450-MC damped wave taken with Tektronix 517A oscilloscope, H-P 196A camera set at f/1.9, Type 47 Polaroid film.

Accessories

Polaroid Fast Film

Polaroid Corporation has introduced a new film (Type 47) so fast (daylight exposure index of 3000) that it can be used to record single CRO transients with rise times less than one millimicrosecond—transients of such high speed that they are invisible to the eye.

Fig. 15 shows a record of a single-shot 450-Mc damped sine wave. A measurement of the fastest visible part of the trace indicates a writing rate of over 3000 cm per microsecond.

The new Type 47 Polaroid Land Picture Roll will fit in any standard Polaroid Land Camera. Best results for recording fast transients are obtained on the blue P11 phosphor. With special prefogging techniques, further increases in maximum writing rates are possible, exceeding 8000 cm per microsecond.

Wollensak Oscillo Raptar Lens

The new Wollensak Oscillo Raptar six-element anastigmat lens is designed especially for oscilloscope recording to provide a distortion-free, curvature-free anastigmat lens with fine resolution and sharp corner definition. The 3″-focus, f/1.9 lens is made in two types—one for 1:0.9 reduction and one for 1:0.5 reduction for 3″ x 4″ format. It generally is supplied in a #3 Alphax shutter, with optional synchronization.

Pressure Recorders

This view of pneumatic-signal recorders continues our series on recorders. It includes static-pressure, differential-pressure and receiver types.

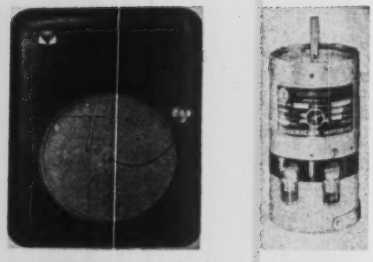
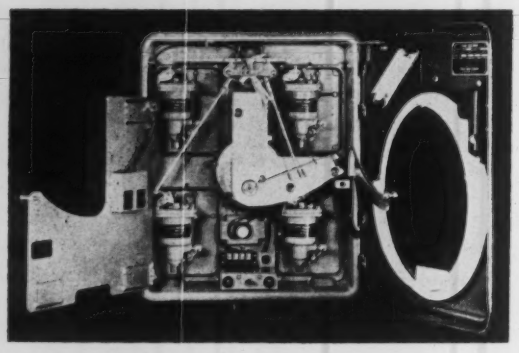


FIG. 1. AMERICAN METER pressure recorder and Gasclock.



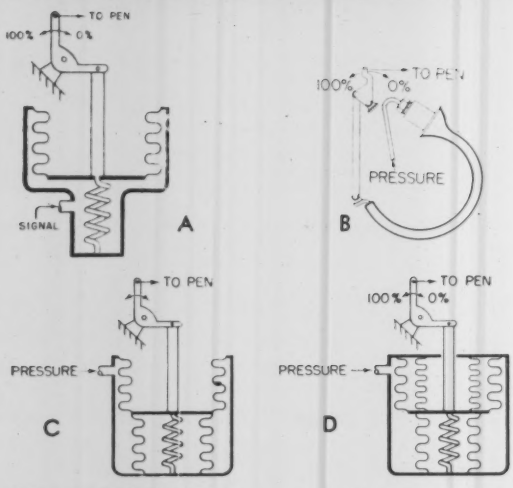


FIG. 2. BAILEY four-pen pneumatic receiver recorder with four Class 8 bellows transducers. Bottom shows cross-section of Bailey transducers for various pressure ranges and measurements.

MOST PRESSURE RECEIVERS use a bellows or a bourdon tube as a pressure-to-position transducer. The thrust, displacement and simplicity of bellows make them popular for positioning recorder pens and for other low-pressure service. A bourdon-tube transducer usually is selected for intermediate and high pressures, and when lower pressures need only be indicated.

The following pressure recorders and indicators are available commercially. Most have accessories available for control, but this description applies only to the recording units.

American Meter Co.

American pressure recorders (Fig. 1) for one or two pens are available in ranges up to 10,000 psig. Bellows elements are used for ranges below 50 psig. Helical spring elements of Ambrac are used for ranges up to 500 psig. Stainless steel is used for higher ranges and a Ni-Span element is available for 0-1000 psi.

Mechanical or electric chart drives provide 24-hr or 7-day rotation.

American also supplies a "Gasclock" air- or gas-powered instrument timing unit. Normal gas or air consumption is 5 cu ft/hr at 5 psi. Rotation is 2 rpm. Accuracy is ± 1 minute per day and is not affected by a ±20% variation in supply pressure. Mechanism is self-starting and provides 4 inch-ounce torque.

Bailey Meter Co.

The Bailey pneumatic receiver (Fig. 2, top) drives a recording pen or recording pen and integrator with factory calibrated accuracy within ±0.5% of chart range span at ambient temperatures between 40°F and 140°F. Standard SAMA signal ranges are 3-15 psig or 3-27 psig. Recorder has up to four pens fed by one-year sealed plastic ink sacs.

Fig. 2 shows operation of four basic transducers available as plug-in elements. A shows Class 8D for recording direct-connected pressure in standard ranges of 0-10, 15, 20, 25, 30, 35 psig; and 0-20, 25, 30 35″ Hg. B shows bourdon tube element with a maximum range of 0 to 7500 psig. C shows gage pressure (Class 81) or vacuum transducer (Class 82) with ranges of 30″ Hg to 25 psig and 0 to 30″ Hg. D shows Class 84 absolute-pressure transducer for 0 to 20 psia. Bellows units work against Iso-Elastic springs.

Barton

Barton Model 202 recorder (Fig. 3) converts differential pressure into a shaft rotation that is taken through a torque tube to a linkage attached to a standard inking pen and a 12″ meter chart. The patented rupture-proof bellows is formed of selected stainless-steel sheet that is stamped into wafers and seam welded. An extra bellows attached to the high-pressure side of the bellows unit assembly takes up expansions and contractions of the fill liquid within. Iso-Elastic spring assemblies balance the differential pressure applied to the unit. They are available in interchangeable units with ranges from 0-20″ W.C. to 0-50 psi. External accessable pulsation dampening by-pass the fill liquid through a restriction. Depending on the service, the meter is self venting or self draining due to the arrangement of the pressure port connections.

Response speed is approximately 100 milliseconds undamped. Signals up to 3 cps can be recorded with practically no attenuation.

Helical pressure elements are available in a variety of materials including brass, beryllium copper and stainless steel for static pressure ranges from 30″ MV (mercury vacuum) to 10,000 psi.

Chart rotation can be 96 seconds to 30 days; drive can be electric or spring.

FIG. 3. BARTON differential-pressure recorder.

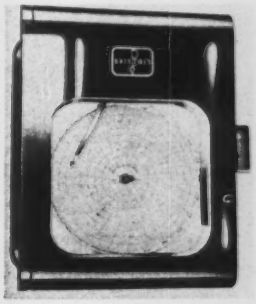


FIG. 4. BRISTOL 500 Series round-chart model.

Bristol

Bristol's 500 Series receiver recorders (Fig. 4) are designed for pressure ranges from 0-6 mm mercury absolute up to 0-10,000 psi and higher, and including vacuum and compound ranges. Round charts are 8″ or 12″ electric or spring-driven. Up to four pens available in 12″ size.

A Model 28 vertical strip chart recorder also is available for the same ranges. Chart drive is electric; speeds are from $^3/_4$″ per minute to 12″ per hour. A Model 44 4″ round chart recorder also is available.

Capsular and bourdon tube elements are available in brass, beryllium copper, phosphor bronze, Ni-Span C, or 316 stainless sheet.

Features include pulsation dampening; over-range protection and temperature compensation are available.

Accuracy is ±0.5%. Response speed is 90% of full scale in less than 0.1 sec.

Bristol's Series 650 Metagraphic plug-in one- and two-pen pneumatic recording receivers and indicators include 39 models. All cases are the same size (Fig. 5), occupying a 5″ x 5$^1/_8$″ panel area; record is a 3″ horizontal strip chart. All have plug-in interchangeability and can be removed from the front of the panel. Self-sealing sockets permit making and breaking connections without disturbance to the system.

The instruments receive a 3-15-psi air-pressure signal, but can be furnished to order for 3-18 psi, 5-25 psi, 3-27 psi, and 0-30 psi signals. The recording chassis uses multiple-diaphragm measuring elements; the indicating models use a bourdon pressure element; all include pulsation dampers to smooth out sudden surges in the signal. Accuracy is ±0.5% full scale.

Chart drives may be electric or pneumatic, and are interchangeable. Pneumatic drives provide speeds of 1 and 2 inches/hour. Electric chart drives provide

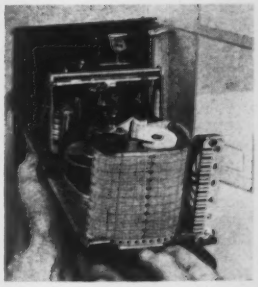


FIG. 5. BRISTOL Series 650 receiver recorder can be slid forward for span and zero adjustment and chart service.

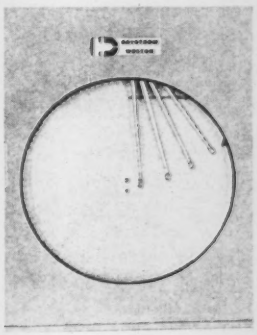


FIG. 6. DAYSTROM-WESTON pressure recorder; receiver recorder is similar with up to three pens.

speeds of 1, 2, or 3 inches/hour; also speeds of 1, 2, or 3 inches/minute are available.

Attachments available include a chart cut-off, a pneumatic integrator, and a ratio control system. Control models also are available.

Daystrom-Weston

The Daystrom-Weston pressure recorders Model 7711 (single pen) and Model 7712 (multi-pen) have 12″ chart, 4.75″ pen travel (Fig. 6). Standard chart drives are electric or hand wound. The recorders cover

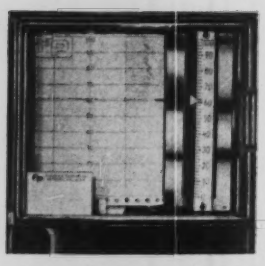


FIG. 7. FISCHER & PORTER Series 1200 recorder.

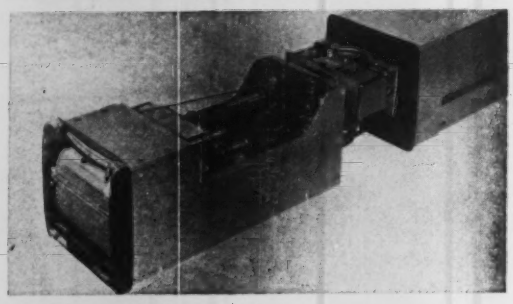
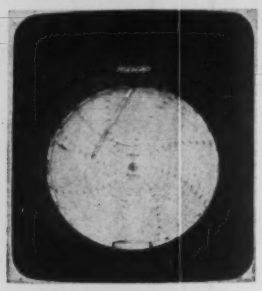


FIG. 8. FOXBORO M/54 receiver recorder (top); Model 42 (left) can have up to four pens.



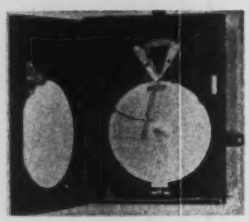
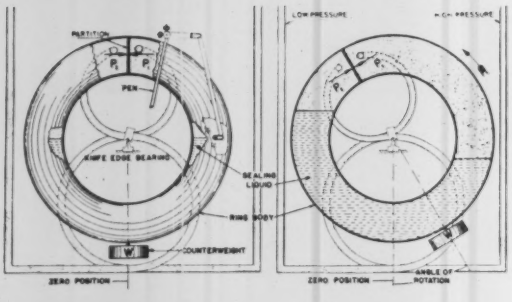


FIG. 9. GENERAL CONTROLS J-200 Series.



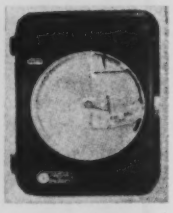


FIG. 10. HAGAN ring-balance operation. Difference in pressure against partition rotates ring. 6000 Series is shown at left.

the range of 30″ of vacuum to 7500 psig. Accurately calibrated bellows or bourdon springs serve as the actuating element according to the pressure range. Absolute pressure ranges are from 0-760 mm mercury.

Daystrom-Weston Pneumatic Receivers operate on a 3-15 psig signal. An accurately calibrated bellows serves as the actuating element. One to three pens are available.

Fischer & Porter

Fischer & Porter Series 1102 pneumatic receivers accept a 3-15 psig signal and record on a 12″ circular chart. Transducer is a bellows; chart drive can be spring or electric providing one revolution every 24 hours. Accuracy is ±1% full scale; repeatability is ±0.5%; sensitivity is ±0.2%.

The Series 1200 miniature recorders (Fig. 7) receive a 3-15 psi signal and record on a 4″ strip chart. Transducer is a 3″ Ni-Span C capsule; chart drive is electric. Accuracy, repeatability and sensitivity are same as for Series 1102.

Foxboro

The Foxboro Consotrol line includes the Model 53 and Model 54 pull-out, two-pen receiver recorders (Fig. 8). A mercury bottle switch and automatic interlock provide non-arcing protection when the electric chart drive assembly is withdrawn.

Accuracy is 0.5%; response speed is 0.4 sec full scale.

Range bellows receives 3-15 psi signal. Damping is adjustable from the front. Thirty-day chart has 4″ scale width. Speed is ¾″/hr. with ½-hr time divisions. Drive can be synchronous motor or pneumatic impulse type.

Foxboro's line also includes a Model 42 receiver recorder (Fig. 9). Response time is 0.4 sec, full scale. The element is a bronze bellows which takes a 3-15 psi input range. Recorder is available with up to four pens and uses mechanical or electric chart drive with choice of speeds and rotations. Accuracy is 0.5%.

General Controls

Industrial Controls Div. of General Controls offers a J-200 Series of pressure recorders for ranges up to 10,000 psi, including receiver recorders for 3-15 psi pressure signals (Fig. 9).

C-type bourdon tubes are made from phosphor bronze, steel and stainless steel.

Chart size can be 6″ dia or 8″ dia. Drive can be hand wound or electric for 24-hr or 7-day rotation. Accuracy is 1%.

Hagan

Hagan's pressure measuring devices cover a minimum full-scale range of 0.20″ W. C. to a maximum of 3000 psig. The 400-Series instruments and the 4000-Series instruments are used for recording relatively low static pressures—up to 100″ W. C. for the 400-series

and 560″ W. C. (approximately 20 psig) for the 4000-Series instruments. The 400-Series instruments is available with a 10″ dia chart; the 4000 Series instrument is available with a 12″ chart.

Both instruments use the Ring-Balance principle (Fig. 10). A hollow ring half filled with sealing fluid is the primary sensing element. The ring is balanced on a precision knife-edge fulcrum that permits rotation about its axis. The static pressure or differential pressure is applied to the ring through flexible tubing connectors and acts on an integral ring baffle to produce a torque. Rotation of the ring develops a counter torque due to a preselected range weight attached at the bottom of the ring. Thus ring rotation is proportional to the measured pressure. The pen is positioned proportional to the ring motion. These units measure either static pressure or differential pressure. Absolute pressure also can be measured by connecting one side to a vacuum source.

The calibration of the 400 and 4000 Series instruments can be checked by weights supplied with the instruments. Response time for these units varies from less than 1 sec to approximately 15 sec, depending on range and fluid measured.

The 6000-Series recording instruments have a 12″ circular chart and are suitable for measuring static pressures from 50″ W. C. to 3000 psig or absolute-pressure from 5 psia to 200 psia.

Pressure measurements up to 400 psi are made by relatively large-area bellows elements; pressures above these values are measured by spiral elements.

Hays

Hays Model 771 Universal Recorder (Fig. 11) can provide from one to four continuous records of pneumatic signals. Calibration adjustments are accessible on chart plate. 4.4-second full-scale pen travel is available, chart can be 1, 8 and 24 hr or 8-day rotation.

Direct-acting pressure receivers are bellows or bourdon springs. For 5 to 60 psig element is a brass bellows; 65 to 3000 psig uses brass, steel or alloy steel bourdon springs; 5 to 15 psig vacuum uses brass bellows.

Model 221 directly-actuated draft and low-pressure recorder is used to record air and gas pressure, draft, differential pressure, and flow. A slack diaphragm measuring element mounted on the recorder chart plate is directly connected to the measured variable. Suitable springs oppose the diaphragm movement calibrating the instrument. The pen indicates the value of the measured variable on a circular chart. Model 221 is used to record pressure or draft down to 0.2″ water, full scale.

Sensitivity is better than 0.2% of full scale range. Two-pen recording can be provided to record two variables. Chart drive is 24-hour spring wound or 110- or 220-volt Telechron electric clock. Minimum full-scale range is 0 to 0.2″ water; maximum full scale range is 0 to 120″ water. Accuracy is 2% full-scale range.

Manning, Maxwell & Moore

Ashcroft Recording Receiver Duragauges (Fig. 12) have a standard air pressure range 3 to 15 psi. Other ranges include 2-14, 2-15, 3-18, 5-25 psi. Bellows units are used.

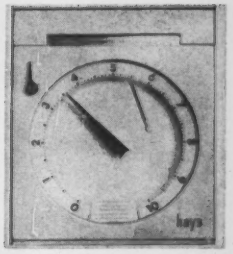


FIG. 11. HAYS Model 771.

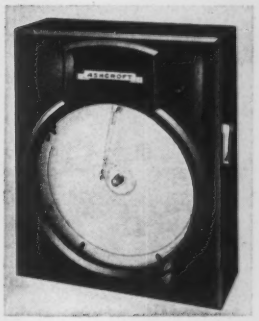


FIG. 12. MANNING, MAXWELL & MOORE Ashcroft Duragauge.

Accuracy is ±0.5% of scale. Actuation is by self-draining bellows. Round 10″ charts for 3⅝″ pen travel are driven by a 24-hour (or other time period) spring-wound or electric chart drive. Features include damping, rupture-proof bellows, overload stops.

The recording receiver is available in all vacuum and pressure ranges.

Minneapolis-Honeywell

Minneapolis-Honeywell's Series 702X circular-chart receiver recorders (Fig. 13) use flat spiral or spring-and-bellows measuring elements. Chart drive has tapered chart positioning stud. Charts are automatically in time when replaced. Hub has friction clutch for initial setting. Chart drive is synchronous motor with starting switch. Standard chart speed is 24 hours per revolution. Other speeds are optional.

One-, two- and three-pen recorders are available with optional air purging, damping assembly (for special applications), auxiliary door nameplate, and internal chart or scale illumination.

M-H Tel-O-Set receiver recorders, series 723X (Fig. 13,B) use a spring-and-bellows receiving element linked to the pen or pointer as shown in Fig. 13, C.

Air pressure pushes up on the bellows (B), compressing the calibrated spring. The bellows pushes up on the center rod (C), which lifts the horizontal arm (D) and, through a Roberts linkage (E), the pen or pointer (F). Pressure range is 3-15 psi. All adjustments and servicing can be done from the front of the panel. Zero and span can be adjusted by a screwdriver when chassis is partly withdrawn from case. Linearity requires no attention.

Charts are 3″ strip type marked in accordance with the measured variable. Chart reroll and daily tearoff is provided on all recorders. 60′ length is sufficient for 30 days at 1″/hour speed. Chart drive is electric—

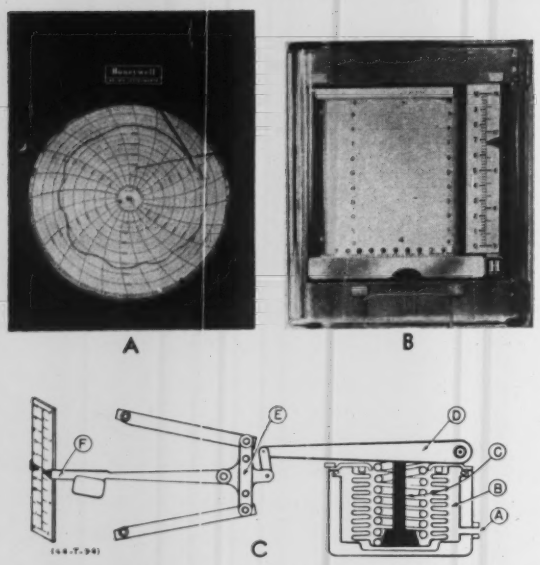


FIG. 13. MINNEAPOLIS-HONEYWELL Series 702X receiver recorder (top). Top right shows M-H Tel-O-Set; bottom shows linkage.

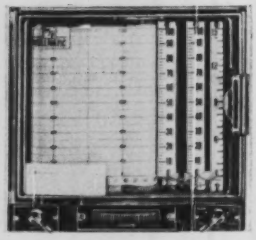


FIG. 14. MOORE PRODUCTS single-station cascade control recorder.

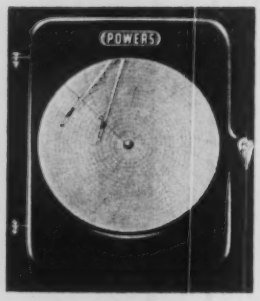


FIG. 15. POWERS Series 100 two-pen recorder.

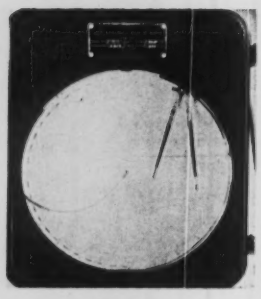


FIG. 16. ROCKWELL differential and static pressure recorder.

115 volts, 50 or 60 cycles a-c. Speeds are 1, 2, or 4" per hour. Air pressure supply of 20 psi is required for pneumatic chart drive. Pneumatic pulse chart speed is 1"/hour.

Moore Products

Moore Models 5310, 5311 and 5320 pneumatic recorders are of the same plug-in style as the recorder-controller shown in Fig. 14. Pressure transducer is a 3" Ni-Span C capsule. Range is 3 to 15 psi. The 4"-wide chart reveals a 14-hr record when chassis is withdrawn partially. Chart drive is electric or air; standard speed is 7/8" per hour.

Accuracy is ±0.5% full scale; response speed is 1 sec full scale.

Powers Regulator

The Powers Series 100 pressure measuring system (Fig. 15) uses a bourdon spiral to measure pressures between 0 and 500 psi; minimum span is 75 psi. Accuracy is ±1% full scale. Chart is 12" dia with 5" pen travel. Spring-wound and electric chart drives are available.

Rockwell Manufacturing

The Rockwell 201 orifice meter (Fig. 16) is a differential and static recording instrument. The differential ranges are available from 0 to 5" through 0 to 400" of water. Static pressure ranges are available to 400 psi. Vacuum and reverse units are also available.

Also available is a Combined Record Gauge. This unit will record the pressures on positive-displacement type meters and ranges up to 1000 psi. The gauge also records cycles which indicate when the volumes being measured were consumed. The index records a standard uncorrected cubic foot record of the volume.

The Rockwell Type "T" Emcorector unit provides a multiple of recorded data: Along with the uncorrected volume, the integrating mechanism provides the corrected volume of the measured gas. The recording device graphically records the line pressure and when the volume was consumed.

Taylor

The heart of the new Transcope recorder is the Servomatic motor (Fig. 17), essentially a power piston with a built-in positioner. These servos are sensitive to changes of less than 0.1% in the pneumatic signals and have 150 times the pen-positioning power of the conventional bellows-type actuator.

The 3-15 psi input signal is received at the input capsule of the servo and positions the baffle against the nozzle. Air is metered to the nozzle through the orifice. As the baffle approaches the nozzle, pressure builds up in the nozzle chamber and over the servo's diaphragm motor. This pressure forces the spring-loaded diaphragm downward, causing the main drive shaft to rotate. A calibrated range spring extends as the shaft rotates, and repositions the baffle, achieving a force-balance condition.

The rotary motion of the shaft and attached pulley is transmitted to the pen assembly by a specially-heat-

treated polyester cable, locked to the pulley. Pneumatic or electric alarms can be attached to the opposite end of the shaft. Zero, range, and linearity adjustments are at the top of the servo assembly. Accuracy is within 0.5%. Maximum response time is 3 seconds full scale.

In addition to the Transcope line, the Transet recording receiver is available in twelve different forms, all with 3-15 psi receiver bellows with 0.5% accuracy and adjustable damping. The 3″-wide strip-chart record displays three hours of visible record. The indicating pointer is located in the center of a dual scale and provides both set point indication and reducing valve output indication.

There also is available the conventional circular-chart Fulscope recorders.

U. S. Gauge

First model in a redesigned line of USG circular chart recorders for pressure is shown in Fig. 18. Recorder can have up to 4 pens. Measuring elements include a bronze bellows for 0-5 to 0-30, 3-15 psi and 0-30″ vacuum. A phosphor-bronze spiral bourdon tube handles 0-15 to 0-8000 psi, 0-30″ vac., compound ranges. A beryllium copper spiral bourdon tube is for 0-1000 to 0-20,000 psi. A Type 316 stainless steel spiral bourdon tube handles 0-30 to 5-5000 psi.

Drive can be either 24-hour spring drive or 115-volt 60-cycle synchronous motor. Other winds, voltages and frequencies are available.

Accuracy is within ±1% of total span. Line also includes 6″-dia single-pen and 9″-dia two-pen recorders.

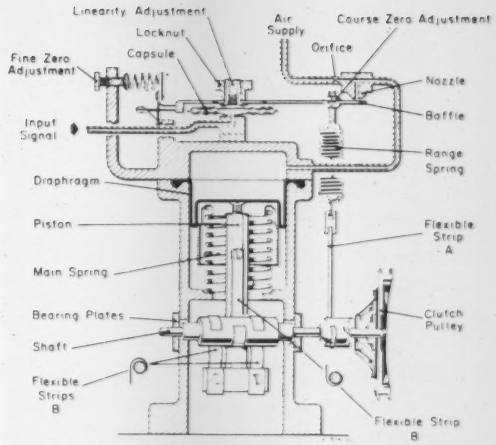


FIG. 17. TAYLOR Servomatic motor uses input signal to vary air pressure on diaphram motor.

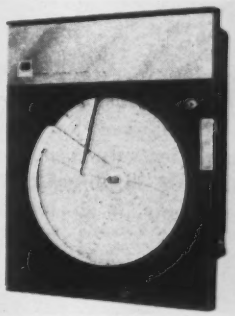


FIG. 18. U. S. GAUGE recorder with 12″-dia chart.

Ceramics do the Special Jobs

INDUSTRIAL CERAMICS now embrace a wide diversity of materials and can be fabricated in an array of sizes and shapes. Heat resistance of up to about 4200°F, combined with thermal shock resistance can be attained readily (Figs. 1 and 2); excellent dielectric properties are obtained easily. But ceramics also provide (1) controlled porosity for predetermined absorption, (2) absence of porosity to limit absorption, (3) design flexibility and miniaturization, and (4) strength and hardness.

Chemical purity, perhaps, has not received sufficient attention. New high-purity grades of Alumina, for instance, contain as little as 8 parts per million of certain undesirable elements. Similarly, extremely pure grades of zirconia are now available which are almost entirely free of Hafnium (0.008%) and which contain as little as 5 to 8 parts per million of Cadmium or Boron.

Photos courtesy Saxonburg Ceramics, Inc.

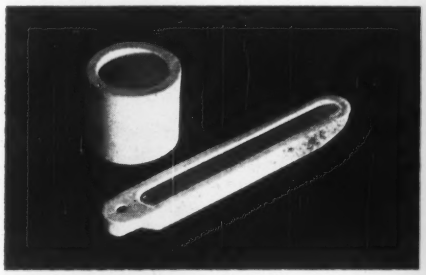


FIG. 1. HEAT SHOCK is the outstanding requirement for chemical boats and crucibles whose temperatures might rise from room temperature to 3200°F within 45 seconds. These high-purity Zirconium Silicate boats will withstand 3500°F and resist penetration by stainless or silicon steel slags.

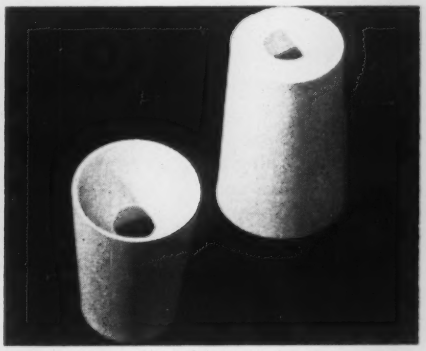


FIG. 2. STABILIZED ZIRCONIA pouring nozzles must withstand 4200°F without softening. For 3000°F temperatures, refractory alumina or zirconium silicate is also used.

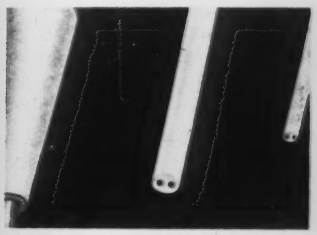


FIG. 3. ULTRA-THIN ceramic thermocouple tubing is contrasted here with the thinlead of an automatic pencil. This product is produced as small as 0.030″ O.D. with two holes each only 0.006″ I.D. The material is extra-high-purity magnesia.

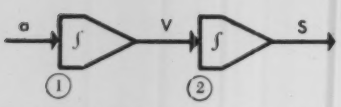


FIG. 1. METHOD OF obtaining voltages proportional to velocity and distance traveled, from a voltage proportional to the acceleration.

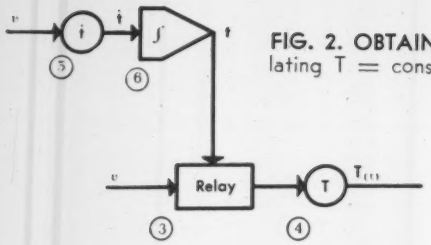


FIG. 2. OBTAINING a voltage for simulating T = constant for a given interval.

The EDA

Simulation is the use of electronic analog and/or digital computers to determine the dynamic behavior of physical systems. Simulation can be mechanized on direct-analog, electronic differential analyzer, digital differential analyzer, general-purpose digital, special-purpose computer, or combinations of these. Here are the specific advantages and limitations of electronic differential analyzers—plus some cost factors.

JOHN MCLEOD
Convair-Astronautics

ELECTRONIC DIFFERENTIAL ANALYZERS have unique advantages which have not been as well publicized as some of their limitations. The most important advantage stems from the analogy between the electronic model and the physical system under study, the characteristic which justifies the popular name "*analog computer*." As the analog can be made as detailed or as general as the problem warrants, and as parameters can be changed with the turn of a dial, an engineer working with an analog computer can observe the effect of changes as they are made and thus acquire a "feel" for his problem which he could not get from any number of numerical solutions. For this reason it has been said that analog computers would earn their keep even if they never "solved" problem one!

The Analog Computer

An analog computer is a group of "operational amplifiers" and related equipment suitable for solving sets of ordinary, simultaneous, nonlinear differential equations. Operational amplifiers are capable of accepting several voltage inputs, multiplying them by constant integers, and summing and/or integrating the result with respect to time. They are usually associated in an analog computer with a stable reference voltage and power supply, a number of potentiometers for "multiplying" by fractions, multipliers for multiplying by variables, resolvers for changing coordinate systems, function generators for introducing empirical relations, switches, relays, etc., for controlling and monitoring operation and, finally, recorders and plotting boards to record results. All of these components operate on voltages, which are made analogous to the variables of the physical system. In the general-purpose analog computer the components are connected together by means of patch-cords.

A Typical Problem

Let us assume that we wish to study the effect of changing various parameters of a short-range rocket in order to arrive at an optimum design. Let us assume a constant weight and a constant thrust for a definite duration of time. Then we start with the basic equation based on Newtons second law of motion:

$$F = ma \qquad (1)$$

and solve for the highest derivative:

$$a = F/m \qquad (2)$$

where a = acceleration along the flight path; F = summation of longitudinal forces acting on the rocket; m = total mass of rocket.

If the thrust, T, and the aerodynamic drag D are large compared to the weight of the rocket, the total longitudinal force, F, on the rocket can be expressed:

$$F = T + D \qquad (3)$$

We have said that the thrust will be a constant, T, until the cut-off time t_c, and then it will be zero so the thrust as a function of time will be:

$$T(t) = T \ (0<t<t_c)$$
$$= 0 \ (t \geqslant t_c) \qquad (4)$$

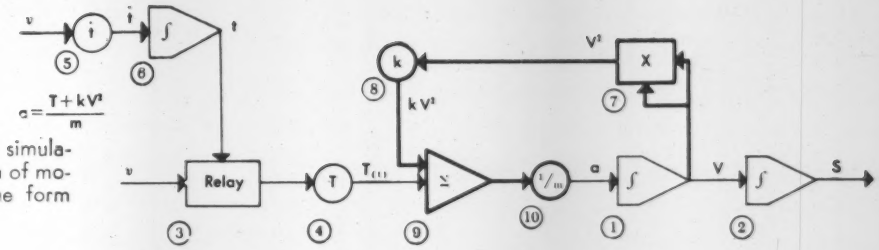


FIG. 3. COMPLETE simulation of basic equation of motion ($F = ma$) in the form $a = (T + kV^2)/m$.

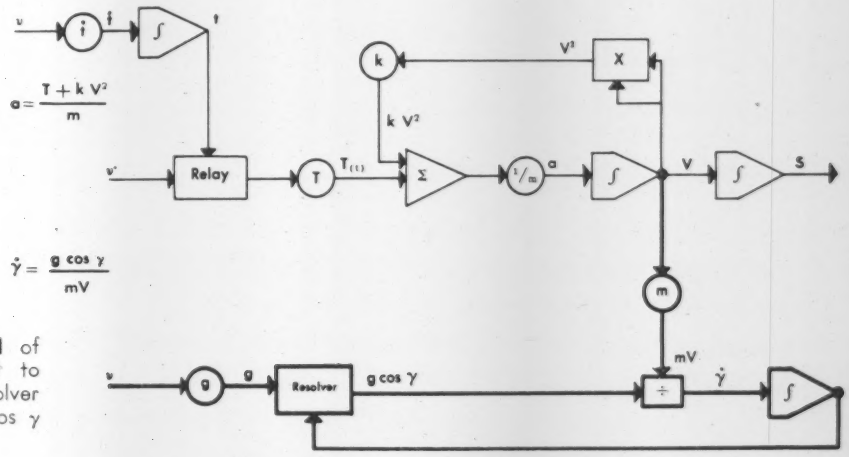


FIG. 4. GENERATION of voltage proportional to flight-path angle γ. Resolver gives g sin γ and g cos γ from γ and g inputs.

We know that the drag force is

$$D = -\tfrac{1}{2}\rho V^2 A C_D \qquad (5)$$

where ρ = atmospheric density; V = velocity of rocket along the flight path; A = equivalent frontal area of rocket; C_D = drag coefficient.

If this is a short-range subsonic rocket, we will not be far wrong if we let

$$-\tfrac{1}{2}\rho A C_D = k \qquad (6)$$

Substituting (6) in (5) yields

$$D = kV^2 \qquad (7)$$

Substituting (7) in (3) and (3) in (2) reduces the complete longitudinal equation to:

$$a = (T + kV^2)/m$$

The straightforward mechanization of this problem on an analog computer is shown in Figs. 1, 2 and 3. Basic to the procedure is the assumption that the voltage analogous to the value of the highest order derivative (in this case, a) can be made available when needed. As shown in Fig. 1 we can integrate this voltage (a) with respect to time in integrating amplifier (1) and obtain a voltage analogous to the rocket velocity V. We can then integrate that voltage out of amplifier (2), and get a voltage which will be proportional to the distance, S, traveled along the flight path.

What do we need to generate the required voltage analogous to a?

The equation $a = (T + kV^2)/m$ says that one thing we need is T as a function of time. The voltage proportional to T must be constant for a specified interval and then go to zero. This is accomplished as shown in Fig. 2. Two voltages are obtained from the computer reference voltage v. One is supplied through a relay (3) to the scale-factor potentiometer (4), which adjusts it to a value proportional the rocket thrust T. To operate the relay the reference voltage v is adjusted by means of potentiometer (5) to some convenient value, $\dot{t}$, and then integrated in amplifier (6), to give a voltage, t, which increases linearly with time. The normally-closed relay (3) is set to open when $t = t_c$, which operation cuts off the simulated thrust.

We also need a voltage proportional to kV^2. This can be obtained as shown in Fig. 3, which combines the circuits of Figs. 1 and 2 with new circuits (heavy lines) multiplying V (which we already have available from amplifier 1) by itself in multiplier (7), to produce V^2. Multiplying this by k in pot (8) generates the required voltage. Now adding this to T in the summing amplifier (9), and multiplying by 1/m in pot 10, gives $(T + kV^2)/m$, which is equal to a. So our assumption that (a) could be made available was justified, and the computer is connected to solve the simple nonlinear second-order differential equation $a = (T + kV^2)/m$, and integrate this twice to get missile velocity and position.

Trajectory Simulation

We have referred to velocity *along the flight-path*. Usually, however, we are interested in the *shape* of the trajectory. This requires that we know the direction of the flight-path—i.e., the flight-path angle as a function of time.

According to Newton's first law of motion, a body in motion will travel in a straight line unless acted upon by forces having components perpendicular, or normal, to that straight line. If such forces are present a missile will turn at a rate such that the sum of the normal forces F_N are exactly balanced by the centrifigal force F_C generated by the turning. That is,

$$F_N = F_C \quad (8)$$

In missile work two additional equations are taken advantage of:

$$\omega = \dot{\gamma} \quad (9)$$

where ω is the angular velocity about the instantaneous center of curvature and $\dot{\gamma}$ is the rate of change of flight path angle, both in radians, and

$$\omega r = V \quad (10$$

where r is the radius of curvature and V is the instantanous linear velocity along the flight path. Then the centrifugal force equation

$$F_C = \omega^2 rm \quad (11)$$

can be used to derive the normal force equation by substitutions according to (8) (9) & (10) to give:

$$F_N = \dot{\gamma} Vm \quad (12)$$

or

$$\dot{\gamma} = F_N/Vm \quad (13)$$

If we consider a "no-lift" trajectory (one in which there are no aerodynamic forces acting normal to the flight-path), the component of gravity normal to the flight path (F_{Ng}) will be the only force turning the rocket. That is:

$$F_N = F_{Ng} \quad (14)$$

But:

$$F_{Ng} = g\cos\gamma \quad (15)$$

By substituting (14) and (15) in (13) we can write $\dot{\gamma} = g\cos\gamma/mV$ and mechanize it to find γ by adding the computing components shown in heavy lines in Fig. 4.

If an x-y plot of the trajectory is desired, it can be obtained by adding computing components as shown in heavy lines in Fig. 5 to mechanize the relationships $V_x = V\cos\gamma$, and $V_y = V\sin\gamma$, and integrating them to obtain and record X and Y.

Refinements

If we wish to examine the rocket performance in more detail we can make our simulation more detailed. If the rocket weight is *not* small compared to the thrust and drag, we can add a term $g\sin\gamma$ (which is already available from the resolver which produced $g\cos\gamma$) to the acceleration to take care of the effect of the rocket weight.

If the rocket is a high-speed missile so that C_D changes substantially with velocity, and long range so that ρ changes considerably with altitude, then the simplification $k = -\frac{1}{2}\rho AC_D$ is no longer valid and the drag force ($D = \frac{1}{2}\rho V^2 AC_D$) must be generated by adding the function generators and mutipliers as shown, and resetting pot (5) to take care of the only remaining constants, ½ and A. These changes are shown in heavy lines in Fig. 6.

Computing elements can be added easily to take care of other effects of interest, such as the change in mass as fuel is consumed, the change in the gravitational force as space vehicles leave this world, etc. The value

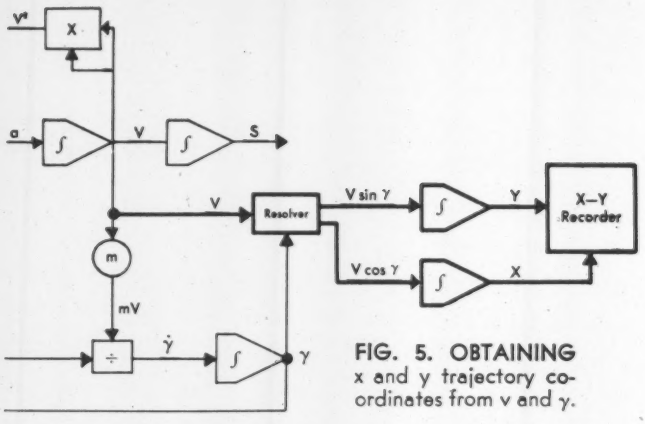


FIG. 5. OBTAINING x and y trajectory coordinates from v and γ.

of any of the variables in the system (represented by voltages generated in the computer) can be plotted out against time or against other variables.

Multi-dimensional Problems

In this problem we have only considered the two-dimensional translational equations in the pitch-plane. In three-dimensional systems including rotational and cross-coupling effects, the mechanization can and does get complicated. Nevertheless this simple example illustrates one of the most important characteristics of the analog computer: An engineer can build with computer components, just as with system components, a system as simple or as complex as required for his purpose.

Advantages of Simulation by EDA

1. Changes in design parameters can be simulated by twisting a dial, or at most by changing a function in a function generator. In our example the effect of increasing thrust can be observed by increasing the setting of pot (4). Or the effect of aerodynamic design can be studied by changing the C_D function generator.

2. Changes in basic design can be simulated by changing patch cords to change the basic model. Perhaps we would like to know what would happen if we put some fins on the rocket in our example. This would require additional computer components to generate voltages proportional to the lift and drag forces created by the fins. These voltages would then be plugged into the $\dot{\gamma}$ and acceleration summing junctions respectively.

3. The engineer is forced to become intimately familiar with the operation of the physical system. It has been said that this alone would justify the use of an analog computer, even if it never actually "solved" a single problem.

4. The speed with which the computer can operate is usually an advantage. The speed results because all elements operate in "parallel" with respect to time. This not only saves operating time to solve a problem, but also allows the computer to operate in "real" time —i.e., in a one-to-one time relationship with the physi-

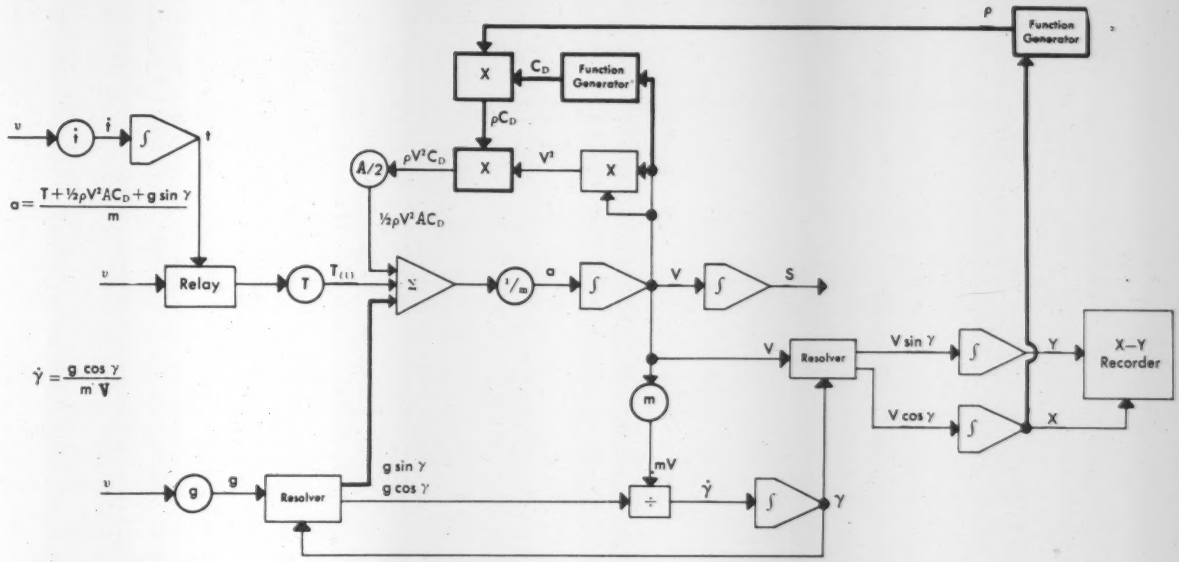


FIG. 6. REFINEMENTS for examining effect of rocket weight changes in the drag coefficient with velocity, and atmospheric density with altitude.

cal system, which is necessary if actual system components are involved in the simulation.

5. The "language" the EDA speaks is often an advantage. Most inputs represent quantities in nature which, in general, are analog rather than discrete. Therefore no "translation" at the input is necessary. At the other end, the output is usually for human consumption, and as most engineers are human (?) and prefer graphs to numbers for the analysis of dynamic behavior, they understand the computer.

Limitations

A limitation talked about most is lack of accuracy. This is overemphasized. True, although most individual components will produce errors of only about one part in a thousand; these can build up in a complex problem to 5% or more. However, analog computers are usually used to simulate hardware whose performance is not predictable or measurable with accuracy that great. Furthermore, computer errors build up in the simulation in the same way that hardware and measurement errors do in the physical system. Thus, for simulation the analog computer is usually as accurate as it has to be.

A more serious difficulty is that of answering the question "How do you know you are right?" Qualified answers may be obtained by:

1. Component checks
2. Static checks
3. Numerical checks
4. Comparison with the physical system
5. Engineering judgment
6. Clairvoyance.

Usually some combination of the foregoing is used to build up the necessary degree of confidence. However, checking is still a problem and is recognized as such by the computer manufacturers who have made, and are making, progress in alleviating it.

One inherent characteristic which may or may not be a disadvantage, depending on the problem, is the inability of the electronic differential analyzer to integrate with respect to a variable other than time. In simulating most physical systems this is no handicap because it is only necessary to integrate with respect to time. In other cases the problem can be set up in such a way as to represent a variable in the system other than time by time in the simulation.

Cost

A rule of thumb is that, on the average, three operational amplifiers will be used for every order of the set of differential equations being mechanized. (This can vary from about one to ten or more for problems involving a large amount of algebra.) Unless you define the type of problems to be solved, three per degree is about as good a guess as can be made.

The price of an analog computer will vary from about $700* per amplifier to perhaps ten times that amount. The lower figure includes a minimum of auxiliary equipment as contrasted to the more elaborate computers with a complete complement of nonlinear, input-output, and special checkout equipment. The cost of the average installation will probably run between $2,000 and $3,000 per amplifier, or from $5,000 to $10,000 per order of the set of equations. (Circumstances can alter these figures by an order of magnitude in either direction.)

If you are willing and able to spend the money, can you simulate systems of any complexity? No! The reliability of an electronic differential analyzer, as with anything else, goes down with the complexity of the mechanization. Thus a point is reached when the equipment simply cannot be made to give useful answers. This point depends on the problem, the equipment, the operator, and the maintenance man.

Some people are cowed by the mere idea of an electronic computer while others can successfully manage complexes of several hundred amplifiers and auxiliary equipment. Moral: pick your operators and maintenance men with the same care you choose your equipment—and pay them accordingly!

*Some unstabilized ones are even less.

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NASH ENGINEERING COMPANY
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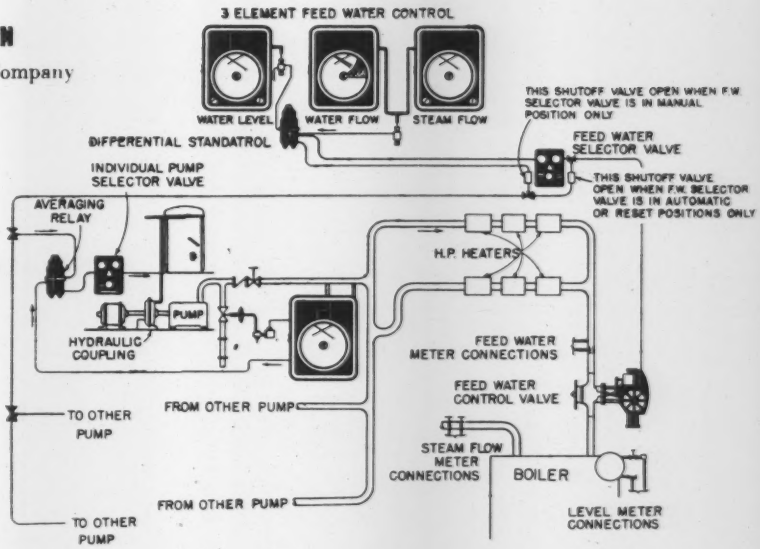
Process Control Systems

FRED D. MARTON
Instruments Publishing Company

THREE-ELEMENT FEEDWATER CONTROL VIA PUMP AND VALVE



Where a constant-speed pump is used in a feedwater line to a steam generator, the throttling valve must be nearly closed at low loads, dissipating and wasting energies of hundreds of horsepower. A variable-speed hydraulic coupling can be used with the pump, and the coupling controlled by the conventional 3-element feedwater control system. In other words, the 3-element system can control the pump rather than the feedwater valve, or it can control both.

In one early system, the 3-element system was used to control the feedwater valve, and the *pressure differential* across the feedwater valve was used to control the pump.

A subsequent installation (shown) employed a similar system, but consideration was given to the possibility of using the pump speed to control the feedwater flow, and only using the feedwater valve for low load operations or under emergency conditions. However, since no experience was available, it was considered prudent to make the installation in such a way that the feedwater valve could be used in parallel, as a means of securing precise and reliable operation.

As illustrated, the three-element control system is connected to a Hand-Automatic Selector Valve, the output of which goes (1) to the feedwater control valve and (2) to the individual boiler feed pumps driven by variable speed couplings. Selector valves (Hand-Automatic) are also provided for each individual pump speed control.

When the main Selector Valve is in the Hand position, the three-element feedwater control governs the speed of the pumps—providing the Selector Valves for the individual pumps are on Automatic—and the feedwater valve can be open wide, introducing a minimum pressure loss into the system. When the main Selector Valve is in the Automatic position, the three-element feedwater control regulates the feedwater valve and, simultaneously, the speed of the pumps. This provides a complete range of control, and offers the reliability of a proven system operating the valve in the feedwater line.

Experience with this installation proved that reliable feedwater control over a relatively broad range could be obtained by control on the pumps only and, theoretically, no feedwater control valve is required. However, the valve is usually included; it can be left in a wide open position during all normal operating conditions. This valve control has considerable value in placing the boiler on the line, and during periods of abnormal pump operation.

Based on this experience, the three-element feedwater control system was applied only to the pump speed, and only remote, manual operation provided for the feedwater valve. The results of this installation lead to the possibility of eliminating the feed valve entirely from the system, and many installations have been made in this manner.

In systems of this type, the pressure at the discharge of the pump is at a minimum, and experience indicates that a feedwater control valve is often needed to increase feedwater pressure, either for operation of the steam attemperator or to obtain circulating water pressure. A feedwater valve installed for these purposes also can be used during start-ups or off-normal operations.

Source: Bailey Meter Co., Cleveland, Ohio.

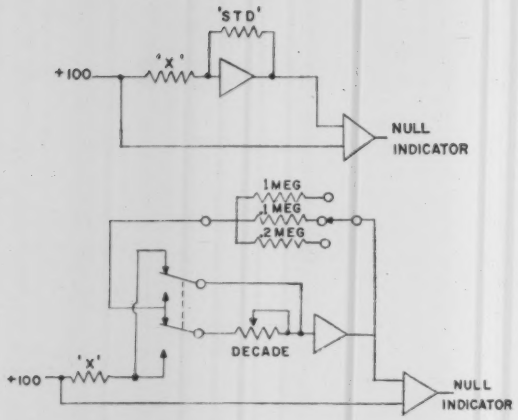


FIG. 1. RESISTOR test. Top shows principle; bottom shows how decade is added in series with either unknown or standard (feedback) resistor.

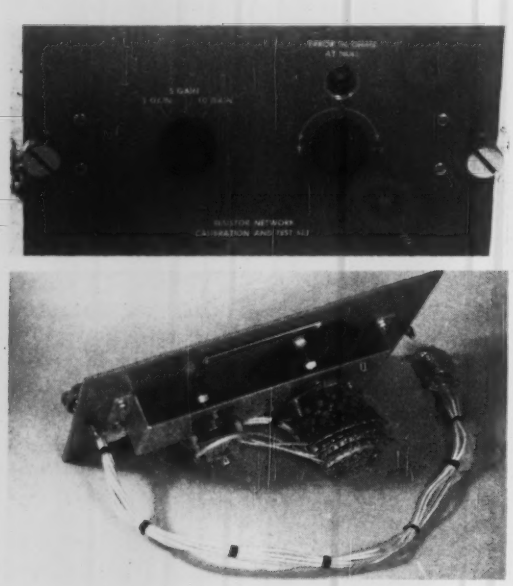


FIG. 2. RESISTOR test panel. Decade has 10-ohm steps from 10 to 100 ohms; 20-ohm steps from 20 to 200 ohms; 100-ohm steps from 100 to 1000 ohms; the 1-, 5-, and 10-gain switch selects decade and corresponding feedback resistor.

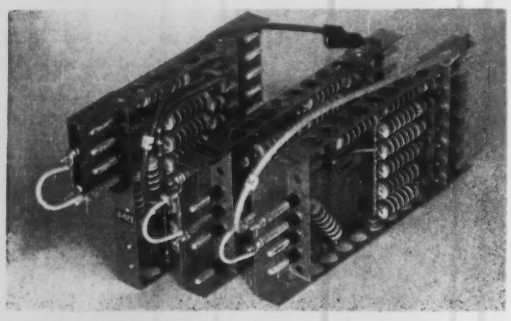


FIG. 3. NETWORK test jumper plug.

Calibration of

R. P. SYKES

Ramo-Wooldridge Div.
Thompson Ramo Wooldridge Inc.*

MANY large general-purpose electronic analog computing facilities have been in operation over two years. Of these facilities, several do not maintain their precision resistors and capacitors in a precisely controlled environment, or oven. Therefore, it is safe to say that a fair percentage of these precision components are sufficiently out of tolerance to degrade the problem solution accuracy by a full order of magnitude from what it was when the equipment was installed. Furthermore, if any precision components have been removed and relocated elsewhere in the computer, the component ratio error will have increased in many cases by a full order of magnitude because of the selective matching of precision components employed initially in several computers.

All analog-computer maintenance facilities should establish a specialized calibration facility and develop test techniques for evaluating their precision components accurately and periodically. Such a facility requires only (1) operational amplifiers, (2) an oven for precision components, (3) a resistor decade box and (4) a modified Wheatstone bridge for resistor measurements. (An "Eput" meter for use in measuring the integrating capacitors will be described later.)

Summing and feedback resistors employed in analog-computer networks are of a high order of precision and cannot be measured accurately by standard bridge techniques because the required match is of the same order of magnitude as the resolution of the best available bridges (0.001%). Since measurement of the absolute value of resistance is of secondary importance compared to measurement of the value of mismatch, an order of magnitude improvement can be realized by measuring the *error* directly, rather than by subtracting two readings of absolute value. An operational amplifier can be used to amplify the error between the resistor under test and a standard resistor.

The resistor test circuit shown in Fig. 1 uses the unknown resistor as a summing resistor, and the standard resistor as the feedback for an operational amplifier. The special decade resistor test panel switching is arranged to permit inserting the decade in series with either the summing (unknown) or feedback (standard) resistor so that the gain of the amplifier can be adjusted to unity whether the unknown is lower or higher than the standard. The decade is

Author was with Space Technology Labs, Inc., when the work covered in this article was performed.

High Resistance Padded Resistors

Analog computers use large numbers of highly accurate padded resistors which determine the gain of the operational amplifiers. The new techniques described here measure the resistance ratios accurately and establish the required corrective padding resistor values, resulting in resistor ratios, and consequent amplifier gains, accurate within 0.001 to 0.005%.

therefore being switched so as to add resistance to the lower of two resistors: if the unknown is low, the decade will indicate "—" at null; if the unknown is high, the decade will be in series with the standard, at null, and will indicate "+".

Since the decade is required to be of the same magnitude as the error in the unknown, its inaccuracy will only affect the estimate of the error, or mis-match, between the unknown and standard; 0.1% decade accuracy will permit measurement of a precision resistor to within 0.0001% (relative to the standard) when the unknown is of the order of magnitude of 0.1% in error:

Resistor error = 0.1% x 1 Meg = 1K
Decade error = 0.1% x 1 K = 1 ohm
Measurement error = 1 ohm/1 Meg = 0.0001%

The special amplifier is used to invert the reference 100 volts, and its output is summed with the original 100 volts in a standard summer using gains of 10.

The output of the second amplifier is metered with a panel-mounted VTVM or DVTVM; the meter accuracy is not critical because the meter is required only to detect a null.

Fig. 2 shows front and back of the test panel, which is engineered to minimize the possibility of operator errors. Setting the left-hand switch to the size resistor being tested (1-, 5- or 10-gain in this case, corresponding to 1 Meg, 200 K and 100 K) automatically masks all but the significant numbers visible in the window above the right hand switch, and makes the appropriate number of zeros appear so that the error indicates directly in ohms on one scale.

The effect of unbalance in the 10-gain summing resistors is eliminated by reversing the input leads and reading "zero" or null as the difference between the two readings obtained. Circuit gains are such that 0.01% error corresponds to the first major division on the meter dial (0.1 volt) so that even the effects of meter zero shift are minute and can be ignored after an initial zero adjustment is made.

The circuit points requiring connection to the amplifiers and unknown resistor are brought from the test panel into the oven through shielded wire.

Each resistor is tested and the errors are recorded on a resistor test card in ohms plus or minus. Then reference is made to a tabulation showing the maximum permissable error in ohms for each size resistor. This tolerance is determined by the computer group relative to the standard they wish to maintain and the amount of work anticipated. We adopted a tolerance of ±0.01% as a temporary measure until all networks were tested. This brought the entire computer up to an "acceptable" standard as quickly as possible. Then the tolerance was lowered to ±0.005% and the networks retested.

Those resistors whose error is equal to or less than the chosen tolerance are checked "OK" on the test card. If any resistors require service the "repair" box is checked on the card and the network is removed for repair.

Certain resistors are not normally available at the patch board and some others are not normally "common" with the summing resistors. Installing a special jumber plug on the rear of the network will complete these connections for test purposes. Fig. 3 shows how these plugs are used on three different networks. A similar adaptation can be made on virtually any network encountered.

Padding

Prior to repair we determine whether the error can be reduced to zero by replacing the padding resistor and what value padder would be required, or whether the entire resistor must be replaced. The padder must be measured to an accuracy within 1% (requiring a Wheatstone bridge) and its value subtracted algebraically from the resistance error. If the difference is negative, it is equal to the value required for the new padder. If it is positive, the entire resistor must be replaced. A simple computer circuit was built which gives this information and minimizes the possibility of human error. It includes (1) a means for entering the error in ohms, plus sign, and (2) a means of reading out the value of the new padder.

Such a computer circuit (Fig. 4) is a modified Wheatstone bridge which permits switching an adjustable pot either in series with the unknown or in series with the adjustabe arm of the bridge. Both adjustable resistances are 1000-ohm, 10-turn, 0.05% pots fitted with digital indicators (the 1000-digit dial reads directly in ohms on the 1000 ohm pot). If the pot labeled "error in ohms" is set to zero the circuit is a conventional Wheatstone bridge. When nulled by adjusting the arm labeled "new padder in ohms," the readout will indicate the actual value of the existing

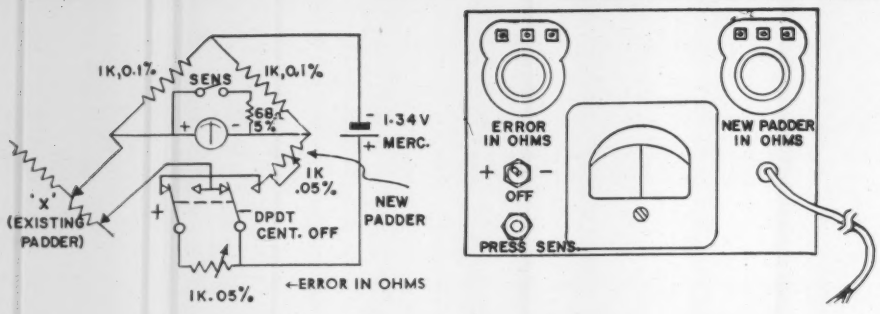


FIG. 4. PADDING-RESISTOR computer.

padder. When the "error in ohms" pot is set to the finite error and the "±" switch positioned so the error value is added to or subtracted from the existing padder, balancing the bridge then causes it to read out the required value of the new padder in ohms. The networks are then repaired as indicated; a heat sink is required in soldering the replacement resistors.

A hi-lo meter sensitivity switch across a resistor in series with the meter prevents the meter from exceeding full scale during preliminary adjustment. The values of the fixed bridge arms and meter sensitivity shown give ample resolution for an accurate null. Each scale mark corresponds to 20 ohms when measuring 1K, and to 2 ohms when measuring 10 ohms.

Following the repair, the leakage from the summer junction to the frame (ground) is measured by a megohmmeter. Conduction from summing junction to ground is a well-known detriment to accurate integrator* operation, and the networks are only one of many places it can develop; 2×10^6 megohms is the minimum acceptable resistance for this test.

The network is then ready for the second preheat and final test (which is identical to the first test).

Amplifier Test Board

As a part of our preventive maintenance program[1] an amplifier test board is used daily to detect network resistors which have drifted out of tolerance. The test circuit involves patching half the summing resistors around to the output, and paralleling the remaining inputs to an input voltage of approximately 90 volts. In this manner, a gain of unity is realized, utilizing all inputs. Any deviation of the output from the input in excess of 5 millivolts indicates a resistor deviation in excess of 0.01% of standard.

Several spare networks will be required to implement this resistor test program without interfering with operation of the analog-computing facility. These spares may be expensive so it is worthwhile to determine the minimum number required.

In order to determine the number of spares needed, take the total number of networks in use and divide by the working days permitted to complete a test of all networks; the result will be the number of networks per day that must be removed because each network is out of use for two days. Multiply this by two to get the total spare networks required. The independent variable is the time allotted to complete a test of all networks. In our installation, three months maximum were allowed arbitrarily to test all networks. We have 84 Type-A, 72 Type-B and 96 Type-C networks, totaling 252. There are approximately 60 working days in 3 months, so networks-per-day equals 4.2. However, we have three types of networks in approximately equal numbers so it seemed expedient to remove either one or two of each type per day. We decided to remove two of each type per day, or six total, requiring 252/6 = 42 days for completion.

Spare Resistors

A stock of spare 0.01% network resistors and spare 1% padding resistors must be procured. If all goes well the great majority of out-of-tolerance resistors can be brought within tolerance by replacing their padding resistors. Therefore a large number of padding resistors will be required in a wide assortment of values, and only a nominal quantity of each size of complete 0.01% resistor-padder assemblies need be purchased.

The wirewound padders usually used in the original equipment cost approximately a dollar each in lots of 50, and deposited-carbon resistors of the same physical dimensions, tolerance and wattage cost about 50 cents in the same quantities; the decision was made to stock deposited-carbon padders. This decision was further substantiated by the argument that even a 5% change in value of a padder, whose resistance only comprises 0.1% of the total, will only change the total resistance by 0.005%. The observed resistance change of the padders due to soldering heat is less than 0.5% typically and 1.0% max.

These ground rules were laid down to determine what values of padders to buy:

A. If the total resistance error is less than 0.005%, no repair will be attempted.

B. If the total resistance error is greater than 0.1%, the entire precision resistor-padder assembly will be replaced.

These criteria established the minimum and maximum values required. Resistors are therefore ordered in 0.005% steps between these limits. This results in the following list, assuming network values of 1 Meg, 200 K and 100 K: 5-ohm steps from 50 ohms to 100 ohms, 10-ohm steps from 100 ohms to 200 ohms, and 50-ohm steps from 200 ohms to 1000 ohms, resulting in 46 values required.

References

1. R. P. Sykes, "Preventive Maintenance Program for Large General Purpose Electronic Analog Computers," *IRE Nat'l Conv. Record*, Vol. 6, Part 4.
2. C. H. Single, "Precision Components for Analog Computers," Beckman Paper No. 56-21-2, Berkeley Div., Beckman Inst.

*To be continued: Mr. Sykes will discuss Integration Error and Associated Measurement Techniques in a future article.

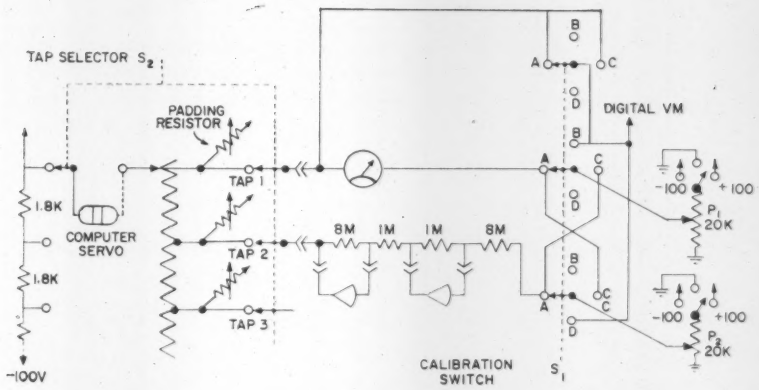


Fig. 1. Operational amplifier holds tap 2 at fixed potential while tap 1 is adjusted.

Calibration Of Padded-Potentiometer Function Generators

This calibration technique uses operational amplifiers to hold one tap of the padded potentiometer at a constant potential while the adjacent tap is being adjusted. Unique feature is that only two precision potentiometers are used.

G. A. KORN

University of Arizona

COMPUTER SERVOMECHANISMS driving tapped potentiometers are in common use as flexible and accurate analog function generators.[1,2] A computing potentiometer (usually wirewound) is tapped, usually from 7 to 25 times. An adjustable "padding resistor" connects each tap to an input voltage ($\pm X$), to ground, or to an open circuit. One can thus adjust the tap voltages so that the potentiometer output voltage will be $Xf(\phi)$, where $f(\phi)$ is a reasonable desired function of the angular wiper displacement ϕ; the potentiometer will approximate linear interpolation between successive tap voltages.

To set up a given function, one must adjust the padding resistors with the potentiometer load connected to the wiper. Unfortunately the various padding adjustments interact radically, so that the adjustments must be gone over as many as 10 times. The pot-padder calibrator used in PACE computers (Electronic Associates, Inc., Long Branch, N. J.) avoids such interaction. The 17 tap voltages of a PACE potentiometer are set up initially on 17 precision potentiometers. A switching arrangement permits each successive tap, say the n^{th} tap, to be set to the correct voltage by galvanometer-null comparison with the n^{th} precision potentiometer, while the $n + 1^{st}$ tap is forcibly held to its desired voltage by a pair of operational amplifiers connected to the $n + 1^{st}$ precision potentiometer. Since the $n - 1^{st}$ tap is already set, interaction between padding adjustments is eliminated.[2]

In view of the substantial cost of 15 or 20 precision potentiometers and dials, a new calibrator unit (Fig. 1) was constructed for use in the University of Arizona's analog computer laboratory. *Only two calibrating potentiometers are needed to set any number of taps to their desired voltages.*

These potentiometers are switched alternately to *set* a tap voltage and to *hold* the subsequent tap at the desired level through a pair of operational amplifiers. The latter are connected in cascade so as to have a high input-impedance (8 megohms) and a low output impedance (less that 0.1 ohm).[2] This low output impedance causes the operational amplifiers to be, in effect, a "battery" of adjustable potential; the output voltage will not vary despite large change in load. As in the PACE design, the operational amplifiers are committed by a special patchbay connection only when the calibrator is needed.

Operation of Calibrator

Let us denote the respective voltages desired at taps 1, 2, etc., by V_1, V_2, ... The precision potentiometers P_1 and P_2 are initially set to V_1 and V_2 by means of their digit-indicating dials, or with the aid of a digital voltmeter. The rotary 4-position switch S_1 is in position A, so that potentiometer P_2 holds tap 2 at V_2. Switch S_2 positions the potentiometer wiper, with the load connected, on tap 1. The padding for tap 1 is now adjusted until a galvanometer null indicates that V_1 is established at tap 1.

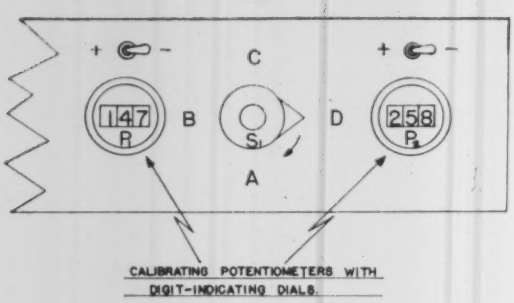


Fig. 2. Front panel controls of calibrator.

Switch S_1 is next advanced to position B; only clockwise rotation is possible. This disconnects P_1 and P_2 from the function pot. The switch pointer-knob on the front panel will point towards potentiometer P_1 (Fig. 2), which is now set to the voltage V_3. P_2 is left alone.

Next, switch S_2 is advanced one position, so that load and balance meter are on tap 2, and the operational amplifier is on tap 3.

Next, switch S_1 is rotated to position C; now P_1 holds tap 3 at V_3, while P_2 (still set to V_2) is used to control the padding for tap 2.

The next quarter-turn advances S_1 to position D, with the switch knobs pointing towards P_2. P_2 is now set to V_4; in this manner, the process goes on until all tap voltages are set. In each case, while one tap is being set the next tap is held at the correct voltage level so that padding adjustments do not interact.

The University's calibrator is combined with a control panel which provides for calibration of up to 6 padded potentiometers and also permits padding networks to be disconnected for linear-potentiometer operation. The cost of the simplified calibrator is below one-fifth of that of the earlier design, with little loss in calibrating convenience and none in accuracy. In the University's calibrator, a digital voltmeter monitors the settings of potentiometers P_1 and P_2 in the respective switch positions B and D as well as the tap voltages, so that the digit-indicating dials are not really needed. The human-engineering design of the front panel (Fig. 2) tends to minimize errors.

In existing (PACE) computers, switch S_2 is located on the padding-network panel rather than on the separate calibrator panel. The new calibrator is so small that it might well be combined with the padding network module, so that S_1 and S_2 could be ganged, if desired.

Acknowledgement

The writer wishes to thank Messrs. H. Koerner and D. Brumbaugh for their help with the construction of the calibrator. The writer is also grateful to the Electrical Engineering Department of the University of Arizona and to Dr. P. E. Russell, Department Head, for their continuing support of this project.

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1. Korn, G. A., Design and Construction of Universal-function-generating Potentiometers, *Rev. Sci. Instr.*, Vol. 21, page 77.
2. Korn, G. A. and T. M. Korn, *Electronic Analog Computers*, 2nd ed., McGraw-Hill, New York, 1956.

ADDITION TO PREVIOUS SURVEY OF PRINTERS

Logger Typewriter

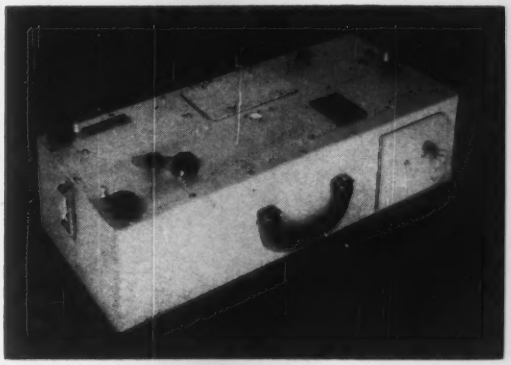
Alphanumeric Typewriter

Full and direct alphanumeric input, output and control for the Bendix G-15 general-purpose digital computer is now provided by the alphanumeric typewriter shown. Every character on the keyboard—upper-case and lower-case alphabetic characters, numbers, symbols, and carriage controls—can be typed into and out of the computer. Speed is 10 characters/sec.

The typewriter is directly alphanumeric because the user types exactly what he sees on the keyboard, as in normal typing. Even the shift key is used in the normal typing manner, and no shift symbols need be programmed. Also, the computer's built-in paper tape equipment can be operated manually from the typewriter. Controls are provided to fully rewind the tape in the photoelectric reader magazine, to reverse the magazine one block, and to punch tape. The typewriter can be operated in alphanumeric mode, or in numeric mode (as with present G-15 typewriters); the desired mode is selected manually, or by a single stored command.

RUDOLPH F. HAUTLY
W. F. Sprengnether Instrument Co., Inc.

CARL KISSLINGER
St. Louis University



PORTABLE SEISMOGRAPH for blast or vibration measurements.

Seismograph Structures

Measurement of ground motion is a unique problem because the entire environment is in motion. Here are the various constructions designed to establish a stable reference point with respect to which ground motion can be measured.

MOTION must always be measured with respect to some frame of reference; thus the fundamental problem of seismometry is to establish some point which remains relatively fixed in space, with respect to which the ground motion can be referred.

The complete instrument for recording ground motion is called a *seismograph*. It consists of the seismometer (detector) with damping, a transducer, a recorder, and some means of marking the passage of time. For some applications various amounts of amplification and filtering are introduced between the transducer and the recorder. In earthquake work it is essential that the record be tied to absolute time with great accuracy. In prospecting or blast measurements, it is only necessary that the passage of time be marked accurately.

Recording the complete motion of the ground requires detection of three components—one vertical and two horizontal components at right angles to each other. In exploration for petroleum and the determination of the depth to rock for engineering purposes, frequencies of the order of 20 to 200 cps are of interest. In recording explosions, such as quarry blasts, frequencies from 1 cps to 200 cps second are observed. In the detection of earthquakes, frequencies are so low that it is more convenient to talk of periods, which range from about 0.5 to perhaps 6 or 8 seconds per cycle for earthquakes near the observatory. In the case of a distant earthquake, periods from 6 seconds up to almost an hour have been determined. As a complete seismograph recording channel acts as a band-pass filter, a complete earthquake recording station should have at least two sets of instruments, each with detection of three components. One is a short-period set (1- to 2-second period) and one a long period set (10-second period or longer).

Basic Seismometer Structures

With the exception of the strain seismograph, the seismometer is always based on a linear mass-spring constrained to oscillate with one (occasionally two) degrees of freedom.

A simple mass-spring system (Fig. 1A) will measure vertical motion. This is done in the Benioff seismograph and in many prospecting seismometers, and requires that the free period of the detector be relatively short in order to keep the dimensions of the instrument reasonable (a ten-second period requires a spring 30′ long). However, if sufficient gain is available through the transducer, the frequency range can be extended by connecting the seismometer to a sensitive long-period galvanometer.

In order to use a mass-spring system as a *displacement detector*, the natural frequency of the system should be lower than the disturbance frequency, as has been discussed previously.* In other words, it is

*Article "Fundamentals of Restrained Motion," April, *Instruments & Control Systems.*

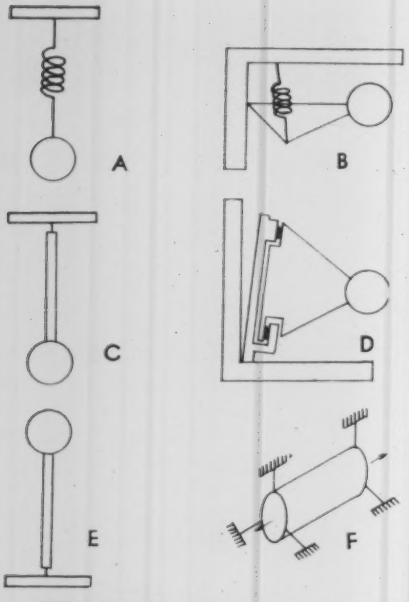


FIG. 1. STRUCTURES for isolating a mass from earth motion. A and B are for vertical motion; C, D, E and F for horizontal motion.

desirable that the seismometer have a long period. Obtaining this long period (low natural frequency) requires ingenious devices for measuring vertical motion. Many use a hinged boom carrying a mass at one end and supported in a horizontal position by a spring (Fig. 1B). As the period is increased, instability caused by variations in temperature and atmospheric pressure are encountered. Using the principle of the zero-length spring, introduced by LaCoste* in 1934, instrument designers have succeeded in producing vertical seismographs with periods of the order of a minute. A long-period vertical seismometer of recent design is shown in Fig. 2.

Horizontal Motion

In principle, the ordinary physical pendulum (Fig. 1C) could be used to detect horizontal ground motion. However, the need for a long period with reasonable dimensions again has led to adoption of a variety of oscillating systems.

Perhaps the most used system is the *horizontal pendulum* (Fig. 1D) in which a boom is mounted so that it is free to rotate about an almost vertical axis. With such a system, periods of 20 seconds are obtained easily. A modern long-period horizontal seismometer based on this principle is shown in Fig. 3.

Another device long used in seismic instrumentation is the *inverted pendulum* (Fig. 1E). Here gravity is used as an astatizing (negative restoring, or unstabilizing) force, and a lengthened period is obtained. This system now finds its chief application in instruments for recording in the vicinity of earthquakes and blasts (Fig. 4).

*L. V. LaCoste, "A New Type Long Period Vertical Seismograph," *Physics*, Vol 5, page 178, 1934.

Fig. 1F shows a *short-period detector*, which has a mass constrained to move in one horizontal direction by elastic members at each end.

In the *torsion pendulum* (not shown) a light mass is mounted eccentrically on a taut torsion fiber; this is a variation of the horizontal pendulum, and is used in the Wood-Anderson seismograph.

Transducers and Galvanometers

The mechanical energy represented by the motion of the inertial member relative to the frame of the seismometer must be converted into a form suitable for recording. In the mechanical-optical type of seismograph, such as the Wood-Anderson and the Sprengnether blast seismometer, this motion is used to rotate a mirror. A beam of light reflected from this mirror is recorded photographically. In this system magnification is provided entirely through mechanical and optical levers.

To provide greater magnification, and to make possible filtering and electronic amplification, most modern seismographs convert this mechanical energy into an electric signal. Many schemes have been employed; the most popular now in use are the *moving-coil* (Galitzin type) transducer, and the *variable-reluctance* transducer. In either, the output is proportional to the *velocity* of the inertial member relative to the frame.

Transducer output usually is recorded by a D'Arsonval galvanometer. A beam of light reflected from a mirror on the galvanometer coil is focused on a photographic record. The galvanometer must have high sensitivity for earthquake work. The free period and degree of damping are selected to give the desired frequency response for the channel.

In general, the *magnification* of a seismograph is the ratio of the trace amplitude to the amplitude of the parameter being measured (displacement, velocity or acceleration), and is a function of the frequency of the ground motion. The frequency response of the seismograph is determined by the free period and damping of both the seismometer and the galvanometer. Many adjustments of these quantities have been employed to meet such special needs such as achieving a response peaked at some frequency of interest, or obtaining a flat response over some particular band. An advantage of galvanometric recording for earthquake observation is that the response of seismographs is low for the high frequencies produced by traffic, wind, and human activities, and for the long-period tilts produced by earth tides.

Recorders

In photographic recording, still the most popular recording method, photographic paper is moved past the light spot by a suitable drive system. In earthquake applications, in which the system must operate continuously, the paper is placed on a drum which is driven along a helical screw. Thus, it is possible to get 24 hours of record on a piece of paper of reasonable size. Chart speeds of 15, 30 and 60 millimeters per minute have been used. Higher chart speeds are required, of course, to resolve the high-frequency ar-

rivals found in the neighborhood of an explosive source. For blast recording and seismic prospecting, speeds of 6 to 24 inches per second are employed. In these cases the record is a tape or strip.

The interval at which time marks are placed on a record also depends on the application. For earthquake observations, marks tied by radio signal to absolute time are recorded at intervals of one minute. For high-speed recording, timing marks are at intervals of 0.02, 0.01, or 0.005 second.

The inconvenience of developing a photographic record to check for an earthquake has led to increased use of visual writing recorders as auxiliary equipment. If a photoelectric cell and amplifier arrangement are used to drive the visual recorder, a single mirror on the galvanometer is sufficient for both recorders.

Applications

Seismographs were originally created to record the motion of the ground resulting from earthquakes. Since waves from a major earthquake penetrate to all parts of the earth, a global network of seismograph stations has developed. The data provided are the chief source of information from which geophysicists have derived the present concept of the internal constitution of the earth.

Special instruments are employed, principally by the United States Coast and Geodetic Survey, for the recording of strong motions of the earth. Usually the recorder of such an instrument is triggered by the first impulse of the earthquake, and recording continues for a sufficiently long time to assure a complete picture of the events that occur.

Waves in the earth also can be used to investigate the local geological structure that must be known in locating deposits of petroleum. The art of prospecting for oil with the seismograph has developed to a high state; closely related to this use is application to the determination of the depth to bedrock, to the ground water table, or to other significant subsurface horizons.

The seismograph can be used also to determine the severity of vibrations created by blasting. This has provided those who use explosives a tool with which to monitor their operations. Similar instrumentation is useful for determining the severity of vibrations produced by heavy machinery, pile driving, etc. A portable seismograph for blast and vibration measurements is shown in the headpiece.

Nuclear Test Monitoring

A pressing international question at present is whether tests of nuclear weapons can be reliably detected by the seismograph. There is no question as to whether the ground waves generated by such an explosion can be detected by the seismograph; the difficulty is in the ability to distinguish between waves from nuclear weapons and waves from earthquakes. There is not now agreement that, if a nuclear test site were located in a highly seismic area, it would be possible to pick out a weapons test from the frequent earthquakes. In addition, as the yield of the device that it is required to detect is reduced, the density of the network of seismic stations must be increased.

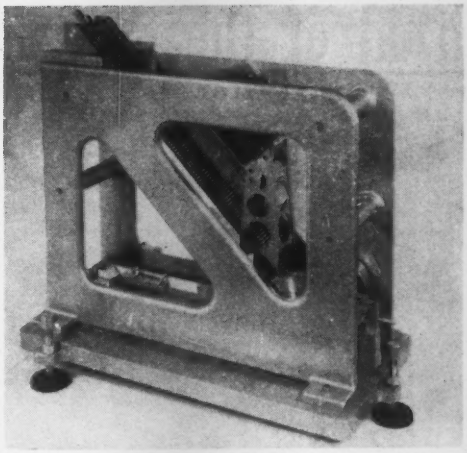


FIG. 2. LONG-PERIOD, vertical-motion detector.

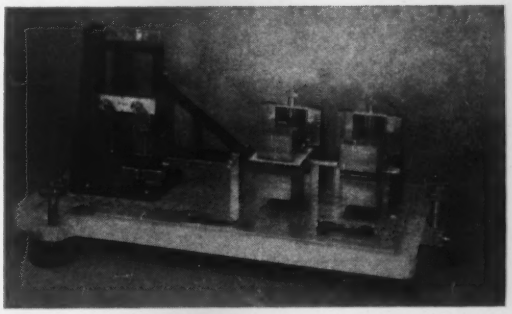


FIG. 3. LONG-PERIOD, horizontal-motion detector using structure of Fig. 1D.

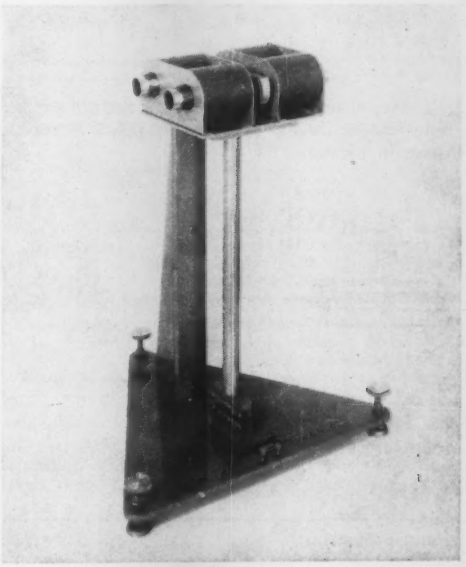


FIG. 4. INVERTED pendulum with mass at top; spring at bottom restores pendulum to vertical.

Journal of the S C M A . . .

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Gas Pressure Regulators

Temperature, time and velocity can be used to alter distribution pressure to compensate for pipeline losses and keep delivered pressure reasonably constant.

ROBERT C. LISK
Fisher Governor Co.

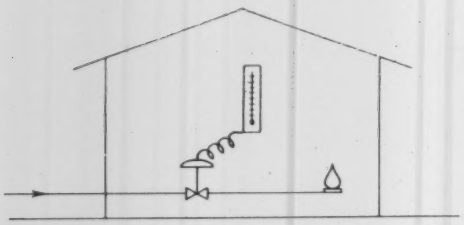


Fig. 1. Temperature-actuated space heater.

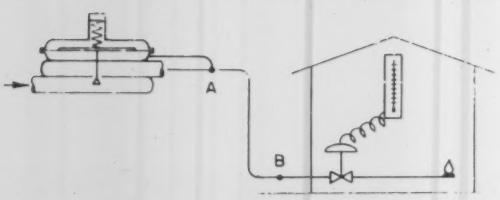


Fig. 2. Pressure regulator delivers constant pressure to point A. However, pressure at point B depends on drop in pipeline.

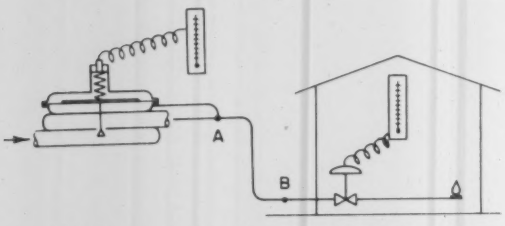


Fig. 3. Pressure at A can be increased when outside temperature falls, thus offsetting pipeline drop between A and B to keep pressure at B reasonably constant.

November Meeting: Thursday, the 19th, Rio Hondo Country Club, Downey, Calif.
Feature: Henry L. Bechard, Product Manager of Thompson-Ramo-Wooldridge will discuss "When to Consider Using Computer Control.

GAS FUELED SYSTEMS, such as space heating systems (Fig. 1), will operate best when supplied with gas at a reasonably constant pressure; variations in inlet pressures must be minimized.

This can be accomplished by a gas pressure regulator (Fig. 2) designed to receive inlet pressure which may vary from 5 psi to 1 psi, and deliver a nearly constant pressure on the downstream side. As the gas required downstream of the regulator may vary from thousands of cubic feet per hour to nothing at all, the regulator must have high rangeability.

The pressure regulator operates to maintain the pressure constant at point A in Fig. 2. However, the more inadequate the piping from point A to point B, the more the delivered pressure (point B) depends on rate of flow.

As rate of gas flow (and resultant service-line pressure drop) is a function of outside temperature, a thermometer can be used to increase the pressure setting of the regulator with falling temperatures and decrease it with rising temperatures (Fig. 3). This compensates for pressure drop in pipelines where there is reasonable correlation between gas load and temperature.

Compensation also can be provided when the gas load has a time pattern, merely by substituting a clock for the thermostat.

A regulator using *both* a clock and a thermostatic element is used widely as a district regulator in gas utility distribution systems (Fig. 4). The regulator is responsive to outside temperature and increases gas pressure output proportionally as atmospheric temperature drops below +60°F. A time clock over-rides and negates the pressure boost provided by the temperature auxiliary during that period when gas requirement is not a function of outside temperature (from late in the evening to early in the morning).

Presented at SCMA-LAHJC Short Course, March 26-27, 1959, Wilmington, Calif.

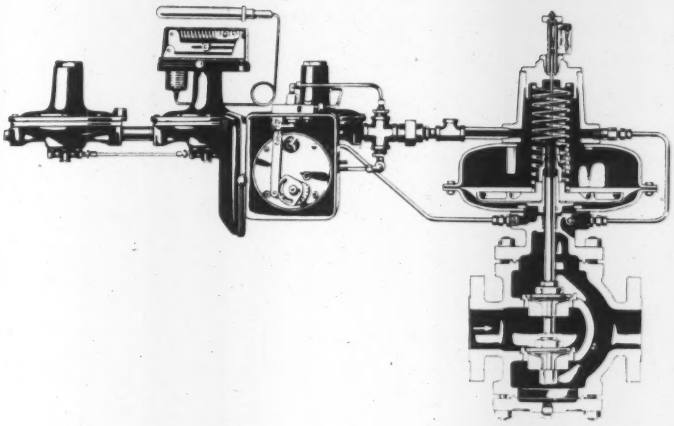


Fig. 4. Time-temperature gas pressure regulator.

Velocity Correction

A more direct compensation for pressure drop between A and B in Fig. 3 is based on the *velocity* of gas flowing from the point of pressure reduction to the building or load. Fig. 5 shows a regulator for doing this. An orifice (19) in the pipeline downstream of the regulator creates a pressure drop proportional to the flow. The differential pressure is imposed on opposite sides of a large diaphragm in the regulator. This diaphragm is linked (4) to the pilot (14) on the regulator proper. As the orifice differential increases with increasing flow, the resulting force across the diaphragm increases the outlet pressure setting of the pilot. This provides velocity-correlated compensation for pipeline pressure loss from the regulator to the point of use.

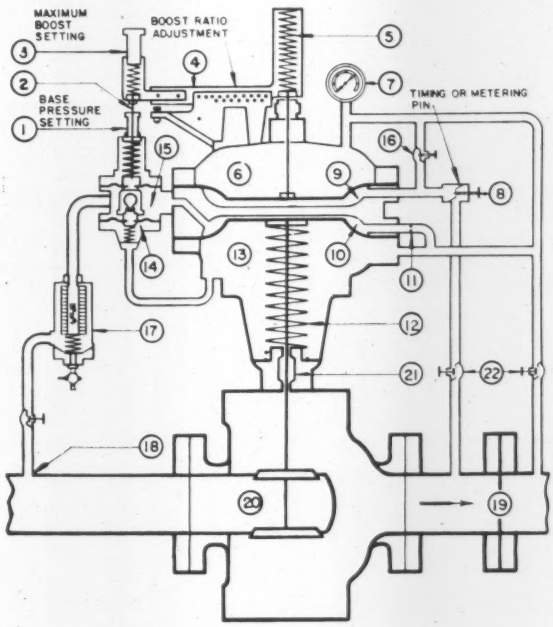
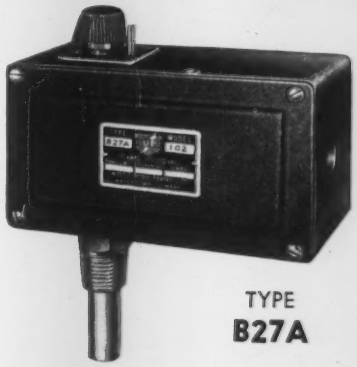


Fig. 5. Velocity compensation.

Calibrated, Dual Switch TEMPERATURE CONTROL **B27A**



TYPE **B27A**

United Electric's Type B27A Temperature Control is a local mounted, enclosed unit that has been designed for applications where it is desirable to control two separate circuits at different temperatures by means of a single control unit. Independent switch adjustments provide a maximum span of approximately 20° F between switch settings, and this span is constantly maintained throughout the control range.

Adjustable Range	Ranges of 50° or 100° F. between limits of 50° and 400° F.
Maximum Difference Between Switch Settings	Approximately 20° F.
Switch Ratings	Up to 15 amps. at 115 or 230 volts A.C. 20 amp. A.C. or D.C. switches also available.
Switch Types	N.O., N.C., or double throw — no neutral position.
Adjustments	By rotating a single turn knob and pointer against a calibrated dial. Individual screw adjustments on switches for adjusting span between switch settings.
Electrical Connections	Via 7/8" diameter clearance hole and an internally mounted terminal board.
Mounting	In any position by the 1/2" NPT on the immersion element.
Enclosure	Cast aluminum case with black wrinkle finish. Bright-dipped brass immersion element.

UNITED ELECTRIC manufactures a complete line of temperature, pressure, and vacuum controls. For special applications, standard units may be modified, or custom-built units may be provided.

For additional information on local mounted temperature controls, including Type B27A, request Section 100 of our new catalog.

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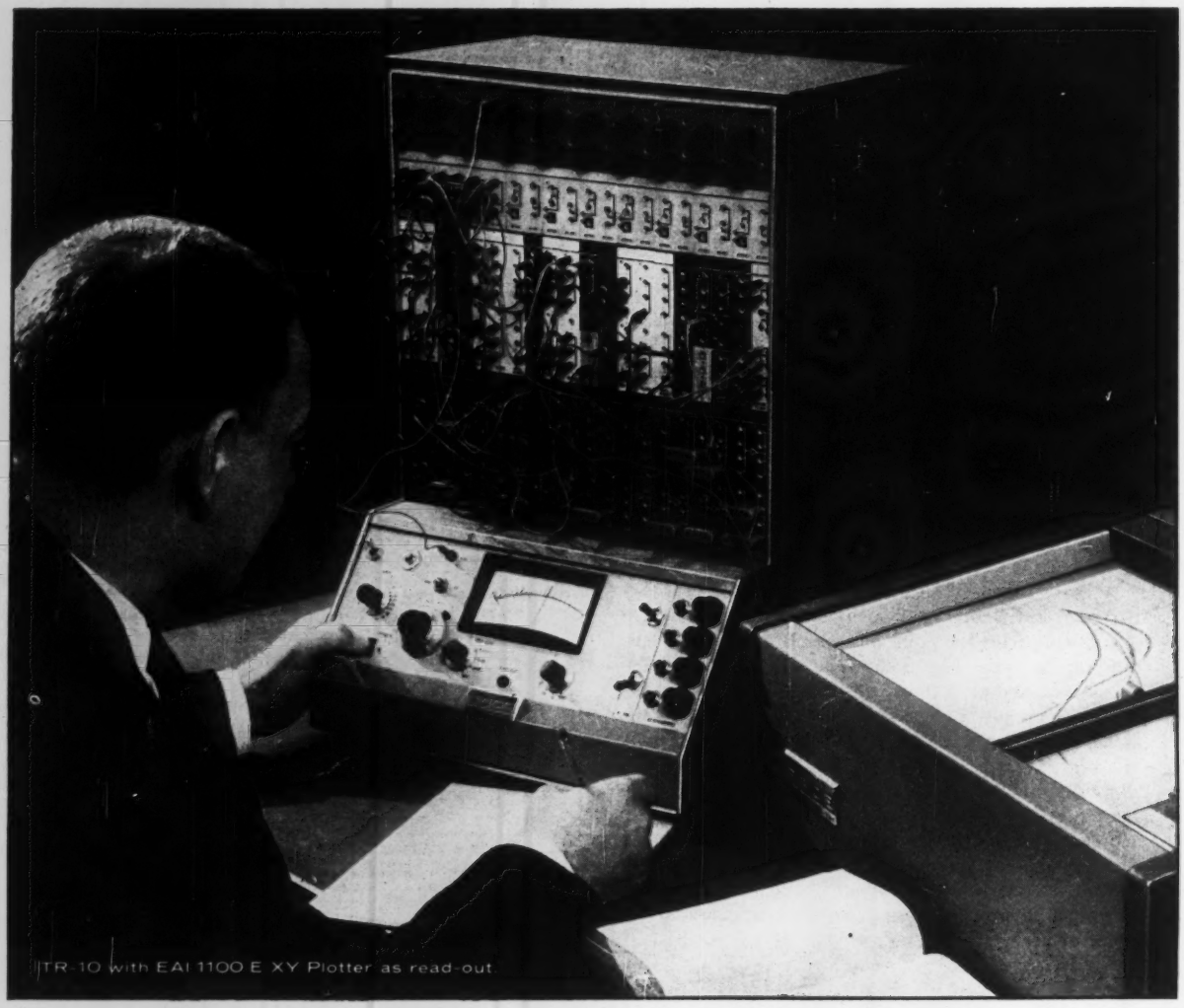

THE *FIRST* ALL TRANSISTORIZED ANALOG COMPUTER

—basic model less than $4000

PACE® TR-10 Eliminates Drudgery—Gives New Insight Into Engineering Problems

This compact unit, 15″ x 16″ by 24″ high, is powered by 115 volts AC and can provide day-in day-out instant solution of your most vexing engineering problems. Even if you have never seen a computer before, you can learn to operate the TR-10 as easily as you learned to use a slide rule.

Simply turn a dial to feed in design parameters, and the computer provides an instant by instant, dynamic picture of the effect of each change. You can study the inter-related effects of heat, pressure, flow, vibration, torque or any variable, and visually compare one with the other. Engineering data comes alive – insight into how new designs will work is obtained easier, faster.

Because of its minimum size and low price, the TR-10 can become your own personal analog computer. You gain first-hand experience with the power of analog techniques, and convert more of your time to *creative engineering*. New ideas that were too costly to try before are now practical. You can design virtually to perfection and have a permanent, visual record of performance before building pilot models or prototypes. As a result, "cut and try" expense is reduced.

The same quality workmanship and design that has made Electronic Associates the world's leading producer of precision general purpose analog computers will be found in this new unit. Accuracy to ±.1 per cent. Modular construction allows you to select varying quantities of the following computing functions: summation, integration, multiplication or division, function generation, parameter adjustment, logical comparison.

***For complete engineering data, write for Bulletin* TR-10-E**

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Long Branch, New Jersey

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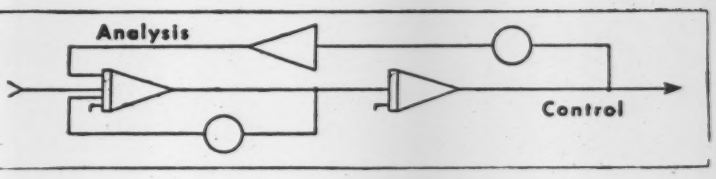
The SIMULATION COUNCIL



Newsletter

John H. McLeod Jr., EDITOR

Suzette McLeod, SECRETARY

8484 La Jolla Shores Drive,
La Jolla, California

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Bits

This month most of the story of the January meeting of the Midwestern Simulation Council as per P. J. Hermann, and a bit of amplification of a Castro-Updike paper from the April meeting of the Eastern Simulation Council.

The Midwestern Simulation Council report covers talks by: *Robert Mudd* on "A Precise Speed-Regulating System Using Operational Amplifiers"; *James Graham* on "Sampling and Quantizing Limitations in Digital Simulation"; *Vincent Rideout* on "Errors and Servo Performance Criteria"; mention of a talk by *Mihajlo Mesarovic* on "Control of Multi-Loop Interacting Systems", and one by *Klaus Frielinghaus* on automatic control for railway classification yards, which will be fully reported next month.

Invitation for Papers

We lead off this month with the following invitation for papers as part of the concentrated effort which the Simulation Councils are making to have this a really interesting and worthwhile meeting for analog and simulation people. Certainly the WJCC is cooperative; they have offered us four sessions (if we can get the papers) and have even used the word "analog" in the invitation. Note also their effort to facilitate "real-time comprehension". Good!

"Computers—Challenge of the Next Decade" is the theme of the 1960 Western Joint Computer Conference scheduled for next May 3, 4, 5 in San Francisco, California.

Special emphasis will be placed on spotlighting the major areas where new planning, and new research and development programs are to be directed to guarantee the foundations for the computer growth destined for the Decade 1960-70. For example, papers on break-throughs in concepts and techniques in the newer areas such as language translation, data retrieval, and self-teaching systems would be of particular significance. It is of course intended that the conference shall also serve effectively as a base for technical papers and discussions pertaining to the current state of the computer art —both analog and digital.

The Conference Proceedings incorporating the papers to be presented at the 1960 WJCC will be distributed at the registration desks. They will be of value to the conference attendee in facilitating not only his post-conference study, but also his real-time comprehension of the technical sessions. Papers to be submitted to the Technical Program Committee should be prepared on the basis of a thirty-minute delivery, extra time being available for discussion. Evaluation will be based on study of an original draft of the complete paper, three copies of which should be in the hands of the committee as early as possible—by November, 1959 at the latest. No advance abstract of the paper will be required, but notification of intent to submit a paper should be provided as soon as possible to facilitate program planning. A convenient postcard form is enclosed for this purpose. The papers will be reviewed, final selection made, and authors notified by 25 January, 1960. The papers must then be received in final form by the Technical Program Committee by 1 March for incorporation into the Conference Proceedings.

The cooperation of all individuals and organizations participating either directly or indirectly in making the 1960 WJCC Technical Program a success will be appreciated.

Pieces

MIDWESTERN S/C MEETING OF 12 JAN ON "ANALOG COMPONENTS IN CONTROL"

About 66 people attended a meeting of the Midwestern Simulation Council held at the Allis-Chalmers Manufacturing Company in Milwaukee, Wisconsin on 12 January 1959. A tour of the Allis-Chalmers facility in the morning was followed in the afternoon by five speakers discussing "Applications of Analog Components in Control Systems" under the chairmanship of *Ralph King* (Caterpillar Tractor Company, Peoria, Ill.).

Ralph first introduced *John Bullock*, Assistant to the Allis-Chalmers Director of Industrial and Community Relations, who welcomed the group and briefly reviewed his company's business operations.

Mudd on Speed-Regulating System

The first speaker was *Robert Mudd* of the A-C Engineering Analysis Section, which is headed by *Dr. Eldo Koenig*, host for the occasion. Mr. Mudd described in some detail "A Precise Speed-Regulating System Using Operational Amplifiers." As this system was also described in a September 1958 AIEE publication "Applications and Industry" under the heading "The Design of a Drive System for a Rotating Arm", your Editor will give only a general description of the problem and solution here.

Allis-Chalmers has an analog-computing facility, Mr. Mudd said, for simulating systems which incorporate the power equipment and control devices which they produce. This requires the simulation of voltage, current, and speed regulators, of turbo-alternators, steel mill machinery and, of late, nuclear reactors.

The specific example Mr. Mudd used was the velocity control of a rotating arm test facility being built at the David Taylor Model Basin for testing models of torpedoes, submarines, and surface ships.

The circular pool shown in the sketch (Fig. 1) is 260 feet in diameter and 20 feet deep. Models are tested by attaching them to a carriage under the arm. Surface ships are usually tested in this basin under condition of no waves, so the arm must accelerate to speeds up to 0.45 radians per second (which corresponds to a speed of 30 knots at 120 feet from the center) and stabilize to within 0.1% within half a revolution, and then hold that accuracy for the other half-revolution while tests are made.

For underwater tests, where waves are unimportant, the system must be capable of 0.71 radians per second (50 knots) in 2½ revolutions. As the arm weighs about 37,000 pounds, and is flexible, and the motor mounted on it weighs 40,000 pounds, this amounts to quite a power control problem.

Fig. 2 shows a simplified diagram of the drive system. Of particular interest to simulation people is the fact that not only was an analog computer used to simulate the overall system, but, as shown, analog components* were incorporated in the actual control system.

Speaking of the simulation, Mr. Mudd explained that it was partially direct in that operational amplifiers in the computer simulated operational amplifiers in the control system, a thyratron was tied into the simulation in the place of the control system thyratron, and a static Regulex was used to introduce the proper time constant.

The simulation also required 18 integrators, about half a dozen inverter-summers, and assorted plug-in resistors and capacitors.

*Beckman operational amplifiers

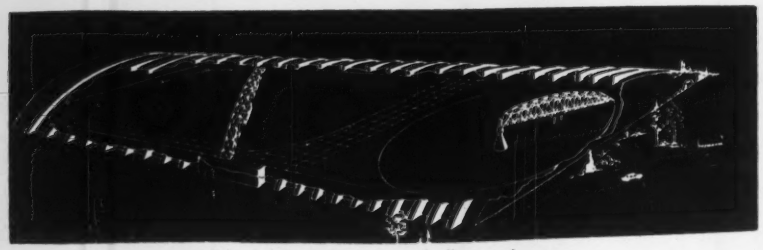


Fig. 1. Rotating-arm hull-test basin.

Graham on Sampling and Quantizing

The next speaker was *Dr. James Graham* (Marquette University, Milwaukee) who spoke on "Sampling and Quantizing Limitations" in Digital Simulations. "I will assume," said Dr. Graham, "That you have not used digital simulation very much and therefore make my remarks fairly general and introduce only some basic concepts and limitations."

Analog simulations have the "niceness" of being able to operate in real time, ease of programming, and of giving a sort of physical feel for what you are doing. And in many cases you can do analog simulations at lower cost.

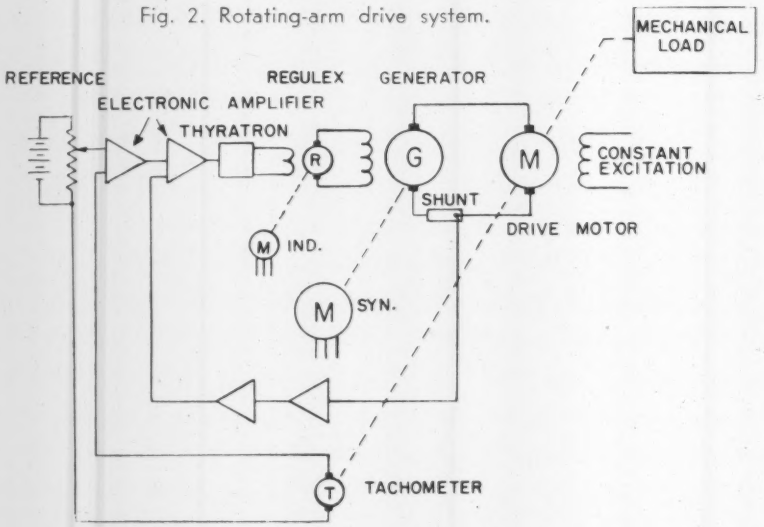
Digital simulations offer the possibility of greater accuracy, and of programming some things that are relatively difficult on an analog computer, like nonlinearities. Sometimes a digital computer is faster, but usually it isn't.

Digital computers have pretty well taken the scientific world by storm in the last ten or fifteen years. Most of us who have encountered Koenig feel that digital computers are capable of doing almost anything. There was the same sort of situation earlier when people used to think you could do anything with electronics. But as we are well aware, there are limitations in electronics and there are limitations in digital computing and digital simulation!

Real-time digital simulation differs from analog simulation in two very important areas: One is the *sampling rate* and the other is the *quantizing level*. *Fig.* 3 shows what is probably the most general type of digital representation of a continuous quanity. Usually digital samples are taken at equal intervals of time or at equal levels of amplitude. The length of the time increments is the sampling period and the levels which the digital device recognizes are quantizing levels.

The sampling period that should be used in simulating a physical system depends upon several things. The two most important are (1) The type of signals, and (2) The system into which they are to be fed. From in-

Fig. 2. Rotating-arm drive system.



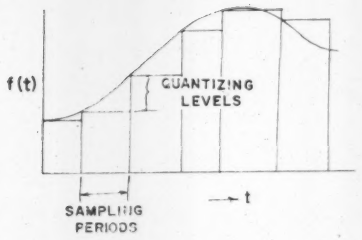


Fig. 3. Digital representation.

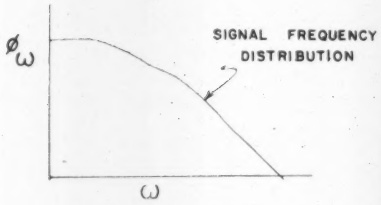


Fig. 4. Data distribution.

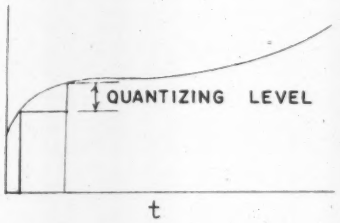
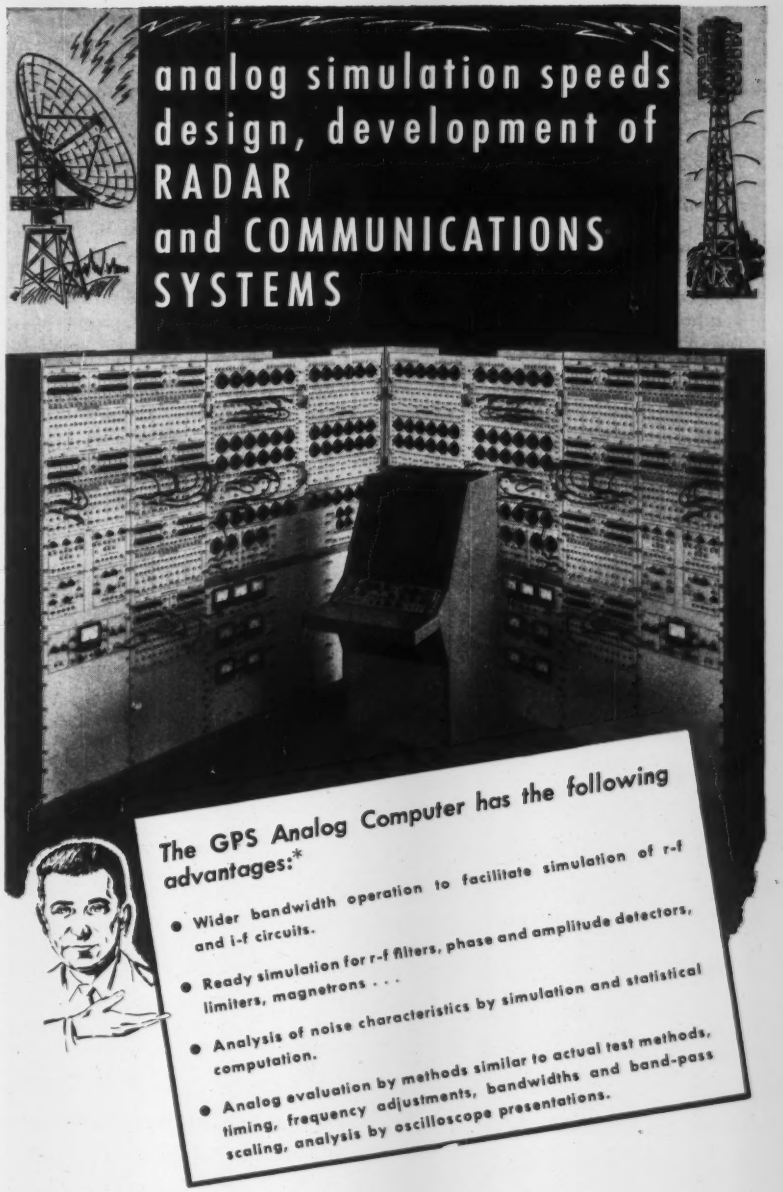


Fig. 5. Quantizing error.

formation and communication theory we get the theorem that the minimum sampling rate should be at least two times per cycle of the highest frequency present in the signal. Thus for a signal having a frequency distribution like that in Fig. 4 the theorem says that if we sample at twice that frequency in which the distribution reaches zero, we should be able, theoretically, to recover all of the information contained in the signal. However, in practice the figure turns out to be five, ten, or even forty times the frequency. This, for our present digital computers, is a serious limitation.

The effect of quantizing levels can be seen by reference to Fig. 5. This is a compromise situation. If the quantizing unit is too large we lose accuracy. On the other hand, if it is small we must make the sampling rate correspondingly fast to realize the potential gain in accuracy.

So at present there are two major limitations to the digital simulation of physical systems in real time which I wish to emphasize in some detail. There are others, such as the sampling durations and ambiguities of sampling instants and things like that, but as they are less important


analog simulation speeds design, development of RADAR and COMMUNICATIONS SYSTEMS
The GPS Analog Computer has the following advantages:*
• Wider bandwidth operation to facilitate simulation of r-f and i-f circuits.
• Ready simulation for r-f filters, phase and amplitude detectors, limiters, magnetrons . . .
• Analysis of noise characteristics by simulation and statistical computation.
• Analog evaluation by methods similar to actual test methods, timing, frequency adjustments, bandwidths and band-pass scaling, analysis by oscilloscope presentations.

The GPS Analog Computer is a compressed-time-scale computer operating with an integrator sensitivity of 3000 volts per second per volt. Because of its wide band width operation, the frequency range of simulation of the GPS Computer is several orders wider than that of conventional slow-speed computers.

*The Defense Systems Department of General Electric, Syracuse, N. Y. selected the GPS Computer for their communication and radar optimization studies. By using analog techniques they propose to save considerable time and money by combining and compressing the stages of the development cycle.

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than the sampling rate and quantizing level by an order of magnitude, we will not consider them here.

John Salzer (Magnavox Research Labs, Los Angeles 64, Calif.) wrote an article* on the frequency analysis of digital computers, which showed that something as simple as an integration on a digital computer requires various numerical techniques. This introduces a new type of limitation—i.e., the numerical techniques, programs, or operations in the digital computer required to simulate the physical system. The more complex the numerical techniques the longer the program will take.

R. E. Graham and *Kelly* at Bell Labs are interested in simulating a certain type of coding for TV signals. Using an IBM 704 to simulate TV pictures for coding, they found they had to decrease the resolution of the TV screen to 1/25 normal. This meant that instead of the usual 500-plus lines they had only 100 lines. Nor did they have as many points across the line as the present standard TV picture. This turned out not to be bothersome at all for their purposes; they were able to study their coding process in spite of the slight decrease in quality. (The picture looked a bit grainy.) Some of the numerical values used: something like 2.4 seconds per frame, 500 samples per second, 100 lines per frame, and each sample had a quantum level of 1024 levels per sample. This gives an idea of the upper limit of intelligible information a digital computer can now produce in real time.

Several refineries are using digital simulators and digital computers to simulate their processes, or parts of them. The aircraft industry apparently still favors the use of analog simulation. The desire to simulate more accurately than is possible on present analog computers seems to be bringing on higher-speed digital computers. However, where analog simulations are accurate enough there is, of course, no reason to go to the more expensive general-purpose digital computers for simulation. As a compromise the less expensive digital differential analyzer (DDA) has been mentioned as a possibility for digital simulation in real time.

* * *

William Peet (Electronics Associates, Inc., Long Branch, N. J.) asked "Are there any particular rules by which you can pick out the sampling rate and quantizing levels?" Dr. Graham didn't think this question could be answered without extensive knowledge of the digital computer to be used and the system to be simulated. Perhaps the best approach would be to solve for the frequency response based on the frequency-response anlaysis to help select the one system of equations to give you the minimum operations for your particular computer. "I haven't worked out any specific rule of thumb to answer your question," he said.

The next question came from *Paul Alper* (University of Wisconsin, Madison): "Couldn't you eliminate the pilot run? I thought its usual function was to pick out a certain quantizing level and to make a run and try another level and compare the two." Dr. Graham answered, "Do you know the accuracy you want in the information you wish to get?". For instance, in the aforementioned TV work perhaps 0.1% was accurate enough. In that case there would be no real need to try to quantize better than that. "It is a matter of judgment as to what level you should work at." Alper then asked if it would be advisable to make two runs to see whether quantizing in a finer level would give significant improvement in the results. This could certainly be done whether or not it depends on the particular applications. The actual analysis of the quantizing level conditions is extremely difficult to carry out on a pencil-and-paper basis. There are several approaches: one is to treat the quantizing level as a noise type of signal, and another is to use a statistical approach and relate the output in terms of the statistical distribution.

Tom Arai (Borg-Warner Research Center, Des Plaines, Ill.) asked about differentiation as a digital process. Dr. Graham explained that there is a similar method carried out by Salzer for a differentiation scheme and referred to in Salzer's paper in the 1953 IRE Proceedings.

A. L. Gardner (General Electric Company, Cincinnati 15, Ohio) asked whether the sampling period must be constant over the full frequency band, as indicated by the transfer function. Dr. Graham replied that it depends upon the particular system. In the usual application referred to in technical articles and textbooks, the sampling period is held constant. "Then the sampling rate is the criterion of the maximum frequency response. I am referring now to a computer such as the IBM 704. What is the maximum rate? I refer to frequency rate rather than time rate." Dr. Graham didn't have that information, but Dr. Koenig spoke up to say he thought it was about 100 cycles per second for the 704.

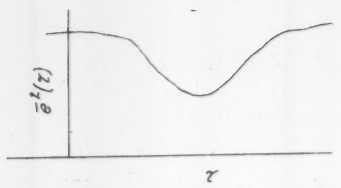


Fig. 6. Generalized error squared.

Rideout on Servo Criteria

The next speaker was *Dr. Vincent Rideout* (Department of Electrical Engineering, University of Wisconsin, Madison), who spoke on "Errors and Servo Performance Criteria."

In a general dynamic system, if the input is designated as r and the output as c, the definition of the error is given as

$$\text{error} = e(t) = r(t) - c(t)$$

One of the measures for error in a system is the average error squared

$$\bar{e}^2 = \frac{1}{T}\int_0^T [r(t) - c(t)]^2 dt$$

In most control systems there is some unavoidable lag, which may be allowable but which must be taken into account in the error criterion. In this case

$$\text{error} = r(t) - c(t + \tau)$$

Here we have the delayed error, which is the difference between the input and the output advanced, or between the input delayed and the output. Now if we apply the squared error equation we get

$$\bar{e}^2 = \Phi_{rr}(0) + \Phi_{cc}(0) - 2\Phi_{rc}(\tau)$$

which may be considered the autocorrelation of the input plus the autocorrelation of the output, both at

$$\tau = 0$$

and minus twice the cross-correlation between input and output, as a function of τ.

The mean squared error criterion is the most popular because it can be handled easily mathematically. On an analog computer, however, some other criterion might be more desirable: the absolute value of the error, for example. Working with analog computers Dr. Rideout and his colleagues began thinking about other criteria, and the idea almost got away from them.

If you plot the delayed or generalized error squared function you get a curve like the one in Fig. 6. For a linear system these curves usually have a minimum at some positive value of τ and peak out at various places elsewhere. The position and depth of this minimum provide a good way of comparing linear and nonlinear systems.

*IRE Proceedings, 1953.

SPEAKING WITH EASE®

An up-to-the-minute report on computer technology prepared by the **Beckman/Berkeley** *engineering staff*

New Advances in Recent Computer for Boeing

A 50 ft. EASE computer shipped to Boeing September 1, is worth looking at as a concrete example of what can be done with the new techniques and equipment we have been reporting in these columns. This all-electronic, digitally-controlled installation is a far cry from the first .01% computers that appeared three years ago. There's too little room to detail all the improvements that distinguish this polished product from the creatures of an earlier age, but let's run through a few more recent advances.

Coordinate Transformations at Electronic Speeds

The servo-resolver, one of the last vestiges of wheel-and-lever analog computing, has finally disappeared. Electronic sine-cosine generators now join with electronic multipliers to translate polar to rectangular coordinates and vice versa. This means that any problem involving resolution can now be handled at computing speed of integrators and summers, that is, at roughly 100 times the speed formerly possible. And accuracy, far from declining as was the case when the first non-linear electronic components appeared, is greater than that achieved with servo resolvers.

This computer can perform fourteen coordinate transformations simultaneously. Sines and cosines are generated with an accuracy of .05%, electronic products with an accuracy of .02%.

Amplifiers that drift only 20μv per week

Drift has been one of the most bothersome faults of amplifiers and one of the toughest engineering problems to lick. Amplifiers in this computer are conservatively specified to drift less than 20μv per day. Tests show a normal drift of less than 20μv per week. Drifting at this rate, the amplifiers require balancing only once a week to maintain .01% integrating accuracy.

The low rate of drift opens up another intriguing possibility: that of balancing grid current against the stable offset, cancelling both sources of error, and thus achieving unprecedented integrating accuracy. We have tried this technique with favorable results. A full report will appear in next month's issue of "Speaking with EASE."

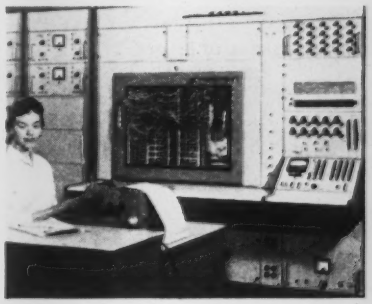
Better Centralized Control

Now you can do more and see more without leaving the console. To wit:

(1) The pushbutton selector enables the operator to inspect voltages at any of up to 1500 points in the computer. Voltages may be read to .01% on the digital voltmeter, to .001% using the analog-type null meter.

(2) Power supply currents can be measured at the console.

(3) A bank of close-set indicating lamps identify overloaded amplifiers by number.



One of two interlocked control consoles, showing Flexowriter used for programming, checkout and recovery of data either manually or by punched tape.

(4) The patchboard is laid out to order; thus assuring the best arrangement of terminals for the type of problem anticipated.

Complete Automatic Checkout

The DO/IT system will scan all desired points in the computer, compare voltages with the proper values, and print out the location of any discrepancies together with the actual value. This enables an operator to pinpoint errors due to patching, mechanization or faulty components without a moment's delay.

The computer has two control consoles. All operation may be directed from one console, thus creating a single large computer, or the installation may be split into two smaller computers, each employed on a separate problem.

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Following are just a few of the possible criteria for errors:

Integrated error:

$$E = \int_0^\infty [r(t) - c(t)]\, dt$$

Squared error:

$$E = \int_0^\infty [r(t) - d(t)]^2\, dt$$

Delayed error:

$$E = \int_0^\infty [r(t - \tau) - c(t)]\, dt$$

Absolute value of error:

$$E = \int_0^\infty | [r(t) - c(t)] |\, dt$$

Integral of absolute value of delay error (IADE):

$$E(\tau) = \int_0^\infty | r(t - \tau) - c(t) |\, dt$$

Integral of time multiplied by absolue error (ITAE):

$$E = \int_0^\infty t\, | r(t) - c(t) |\, dt$$

It is easy to see that we can generalize the error function by making the integrand an arbitrary function of the error, the delay, and time:

$$E = \int_0^\infty F[t(r(t - \tau) - c(t))]\, dt$$

By selecting the appropriate function certain portions of the error signal can be emphasized or de-emphasized, for example the effects of overshoot, or an initial error in a transient response.

Dr. Rideout showed a number of slides illustrating different applications of the various error criteria. He had used an analog computer to develop the illustrations, most of which were for the transient response of second- and fourth-order systems to step inputs.

There are two aspects to the application of this type of criteria:

One is that the customer can explain what he wants by specifying some criterion to be satisfied. And since virtually all control systems have some nonlinearities, the criterion might be one of the nonlinear types that properly fits the job at hand.

The other aspect is that the engineer applying the control system can set up his own criterion to help get good results.

Dr. Rideout concluded his talk with a brief description of the error criteria used in a study of a speed governor loop for a diesel engine at Allis-Chalmers.

* * *

P. J. Hermann (Goodyear Aircraft, Akron 15, Ohio) asked, "Are you going to use this criterion for feedback, or just as a measure?" Dr. Rideout answered that the result was to be used as a feedback in the sense that, having selected the criterion you can adjust the parameters to minimize the result of the error, but the human has to close the loop.*

Dave Sparks (Tammen & Denison, Chicago 5, Ill.) asked whether Dr. Rideout had considered applying some of these methods of linear programming to make automatic adjustments to reach the optimum. Dr. Rideout replied that he felt this was the next step.

He went on to comment on an IRE paper by *Professor Ernst Guillemin* (MIT, Cambridge 39, Mass.) on "What Is Nature's Error Criterion," saying that he felt that nature has no error criterion. We can use the mean square of error because it's nice, it's related to power, and it's easy to handle. But there is good reason to choose others.

It was pointed out that if you are trying to hit a target, a miss is as good as a mile, so there's no reason to penalize for big overshoots.

Vernon Larrowe (Willow Run Research Center, Ypsilanti, Mich.) said he had been bewildered at first because "You were integrating to infinity and getting finite answers. Is that because you were using step disturbances and the error dwindled out?" Dr. Rideout answered yes, that in the case of a step input and a type-one system or higher the error dwindles down to nothing unless you have static friction—which you always do. Thus it becomes even more desirable to use some of these geometrically-defined error functions to take into account such things as residual error.

John Anderson (Allison Div., GM Corp., Indianapolis, Ind.) observed that sometimes the integration was from zero to infinity, but for the squared error it was from minus infinity to plus infinity. Dr. Rideout explained that with transients we always begin the integration at zero, because we consider the transient to have been initiated at zero except when it started at τ. Analytically, the integral for a random input is taken from plus to minus infinity. In practice, though, it's always nice to start things off in a computer at zero rather than try to go back to minus infinity.** We are limited, too, in how long we can carry out this integration.*

Vern Larrowe commented that you can reverse time in analog computers so that you can first integrate from zero to plus infinity, then reverse time and integrate from zero to minus infinity and add the two to get the total integral.**

Professor Rideout distributed some copies of University of Wisconsin Engineering Experiment Station reprints:

"A General Criterion for Servo Performance" by W. C. Schultz and V. C. Rideout; U. of Wis. Eng. Exp. Sta. Reprint #331.

"The Selection and Use of Servo Performance Criteria" by W. C. Schultz and V. C. Rideout; U. of Wis. Eng. Exp. Sta. Reprint #326.

"Correlation Studies of Linear and Nonlinear Systems" by M. G. Spooner and V. C. Rideout; U. of Wis. Eng. Exp. Sta. Reprint #300.

These are available from the University on request.

Mesarovic on Interacting Systems

The fourth speaker, *Dr. Mihajlo Z. Mesarovic*, is a native of Jugoslavia in the United States on a Sloan Fellowship. He spoke on "Control of Multi-loop Interacting Systems" in behalf of MIT and George A. Philbrick Researches, Inc. His talk concerned the development of feedback control loops in multi-loop systems through complex linear active filter systems which will help simplify the problem of control of these multi-loop systems. Unfortunately, Dr. Mesarovic did not supply the Midwestern Simulation Council's secretary with a copy of his notes, and the taped recording of his remarks was unintelligible over the background noise of the auditorium.

Last speaker of the day was *Klaus Frielinghaus* (General Railway Signal Company) who gave a most interesting discussion on use of analog-computer techniques for car sorting in the New York Central's Robert R. Young Yard in Elkhart, Indiana. To do justice to this talk your Editor is holding it over till next month's *Newsletter*.

Updike and Castro on Extraction Calculations

Otis Updike (University of Virginia, now at Cal Tech and UCLA) has sent us "an official copy of the abstract" of the paper, mentioned briefly in a previous *Newsletter* by

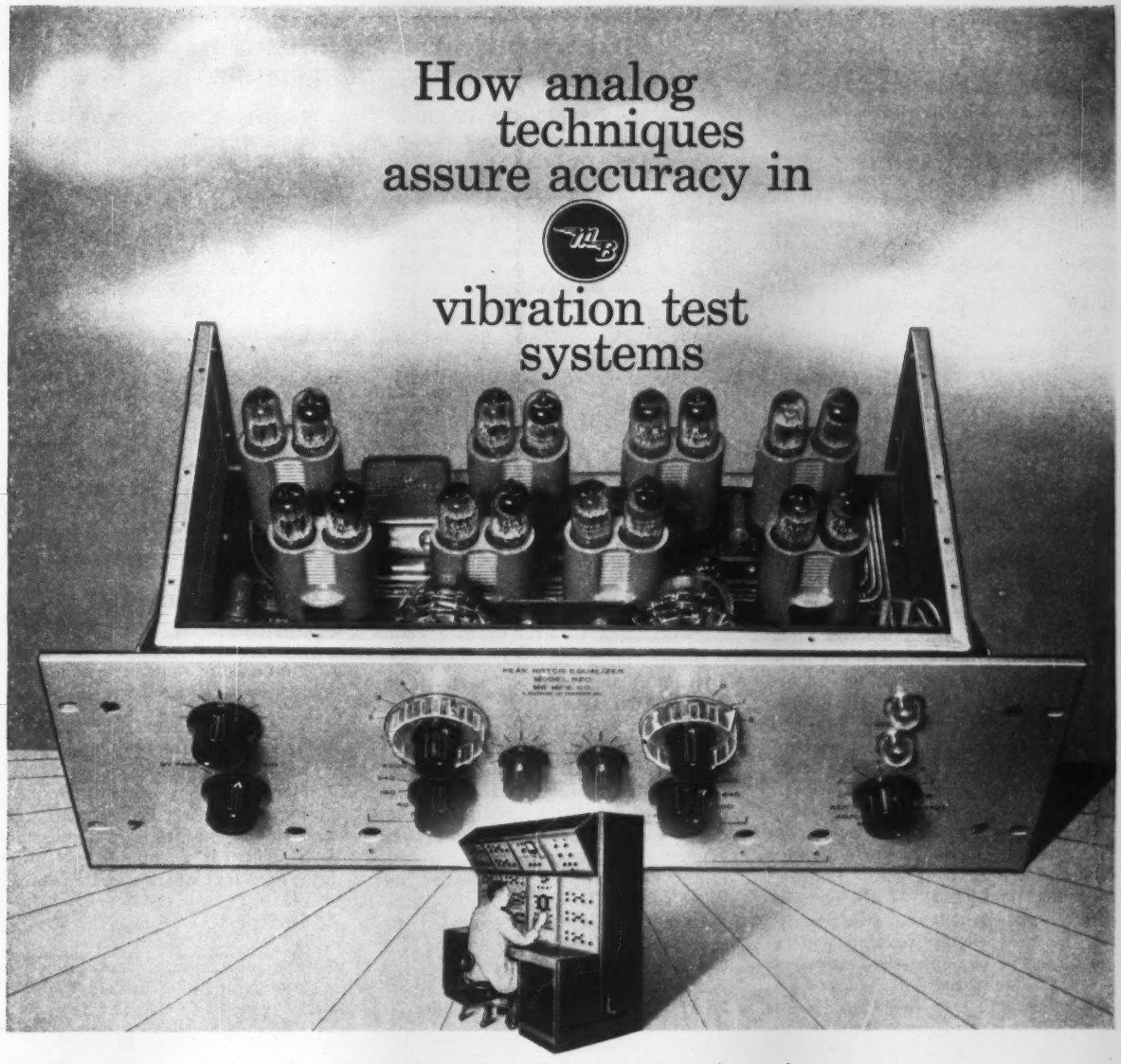
*Why??—Ed.

**Lazy!

*Impatient, too.

**Hear!

How analog techniques assure accuracy in MB vibration test systems



MB Electronics, manufacturer of complete complex motion testing systems, uses modern analog computor techniques to reproduce actual vibrational environments met in the operation of aircraft and missiles.

The MB Model T88 Complex Motion Console, which puts all the system controls within easy reach of a single operator, utilizes 10 Peak & Notch Equalizers — each containing 8 K2-W analog DC amplifiers by Philbrick. The equalizers are the key to test system accuracy. They adjust to the exact inverse electrical equivalence of the mechanical system resonance, and automatically provide the mass offset required for any table loading condition by assuring a flat frequency response identical to that of the input voltage.

GEORGE A. **PHILBRICK** RESEARCHES, INC.
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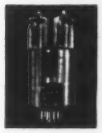
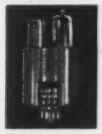
This is a special application, true. But it may provide the spark of an idea as to how you can use analog techniques — and efficient Philbrick plug-ins — to your advantage. Write for freely given opinions on your particular problem.

The analog way is the model way



MODEL K2-W — an efficient foolproof high gain operational unit for all feedback computations, fast and slow. A number of special varieties are also in quantity production. **$24.00**



MODEL K2-P — offers long-term, sub millivolt stability, by itself or with the K2-W. High impedance chopper-modulated input. Filtered output to drive balancing grid or follower. **$60.00**

MODEL K2-WJ — If the rigors of your application deserve a JAN-ized form of K2-W, the K2-WJ is now available. 5751 tubes and MIL standard components are used throughout at no increase in size. **$58.00**

ALL K2 PLUG-INS RUN ON PLUS AND MINUS 300 VDC AND 6.3 VAC. SOCKET WIRING IS SIMPLE AND STANDARDIZED.

CIRCLE 66 ON READER-SERVICE CARD

Otis and Patricio Castro.* This is on "Application of Analog Computing Equipment to Extraction Calculations."

"It resulted," Otis adds, "from a misuse of analog-computing equipment which we perpetrated with some success at the University. Castro applied enough ingenuity and industry to the PACE in computing steady-state stagewise extraction cascades that he was able to show an advantage over more usual methods for large or frequently-calculated systems. Since the equations are large sets of simultaneous, non-linear algebraic expressions, they waste the dynamic capabilities of the analog equipment. At the same time they (1) strain weak operations like division and function generation and (2) require duplicated memory of computing components, either (a) two alternately used storages (which Pat got by using separately-programmed integrators) or (b) manually—or servo-set transfer of output to input as information is "ping-ponged back and forth between duplicate sets of gear—i.e., pots are used as memory elements. Both approaches will work."

Herewith the abstract:

In a study of the speed and accuracy advantages of analog computation for the diffusional operations, several mechanizations of a stagewise, countercurrent extraction cascade were devised. For a ternary system, the simplest setup required six coefficient "pots," eight computing amplifiers (three as active filters), three diode function generators, and a five-cup servomultiplier. This mechanization, though restricted to steady-state problems, yields data on flow rates and compositions between stages as well as on number of stages. It was tested on a Type I liquid-liquid system in which acetone was extracted from water by trichloroethane. After setup, the number of stages could be calculated twice as fast as by graphical methods, with only slightly lower accuracy. Since setup time is longer, the analog method is superior only when many stages (in one or several cascades) are to be computed for the same system. Principal sources of error were the function generators and a division circuit. Changes in both should result in improved performance. Extension of the technique to other flowsheet configurations, to distillation, absorption, or adsorption, and to transient conditions may be made.

*Who, Otis explains, is a member of the "Chilean, or clean-shaven branch of the family"

Information (Without Theory)

From the "Annales de l'Association Internationale pour le Calcul Analogique":

In order to help members wishing to familiarize themselves with the applications of analogy in certain countries, the Association is willing to put them in touch with firms who would agree to take probationers.

We wish to thank our readers in advance for their help in writing to us and in diffusing this information.

With this object, the Association requests Societies and Institutions who would agree to take people wishing to study the applications of analogy in foreign countries, for short periods, to make themselves known at the Editorial offices of the Proceeding of the International Association of Analogue Computation.*

The Association hopes to act as a sort of catalysing agent, promoting the diffusion of knowledge and applications in analogy.

P. J. Hermann (Goodyear Aircraft Corporation, Akron 15, Ohio), Secretary of the Midwestern Simulation Council, says that judging from his mail the most popular Study Group is the one on *Human Physiology and Dynamics* and that a number of M. D's. have asked to be put on the mailing list.

An interesting development!

A while back *Mr. B. W. Littlejohn* of Ocean Falls, B. C., Canada wrote us asking about the meaning of the diagram which heads the Simulation Council Newsletter. Just in case you might be interested, we replied as follows:

"Rather than being intended to represent any one thing specifically, the diagram was selected as a generalization; a sort of abstract symbolizing analog computer diagrams.

"Although the foregoing is the reason that the diagram was selected, it is not meant to imply that it does not have a specific meaning—it does. The triangles with the double line are the accepted symbol for an analog integrator and the other triangle for an analog summer; the circles are the symbol for potentiometers. The tail of the arrow indicates the input to the system, and the arrow head the output. The small lines coming from nowhere and going into the integrators indicate the initial condition, i.e. the value of the variable out of the integrator at time $t = 0$. As shown, the circuit is an oscillator which would produce a sinusoid at the output having a frequency dependent upon the major loop gain and therefore controllable by the potentiometer at the upper right and a damping rate which is the function of the setting of the potentiometer at the lower left. A handy circuit, but selected not for that reason but simply because we liked its looks.

"Don't you?"

To this Mr. Littlejohn replied:

"Yes, I do like the look of it. So much so that I had already painted it on my safety hard hat as an emblem of my trade, namely instrument mechanic. I am glad to say that only one electrician has been foolhardy enough to ask me what it represents. God rest his soul."

Maybe we should sell decals!

*Association Internationale pour le Calcul Analogique, Presses Académiques Européennes, 98, chaussée de Charleroi, Brussels, Belgium.

Information—Request for:

At a recent meeting of the Western Simulation Council the following topics were considered for discussion at future meetings:

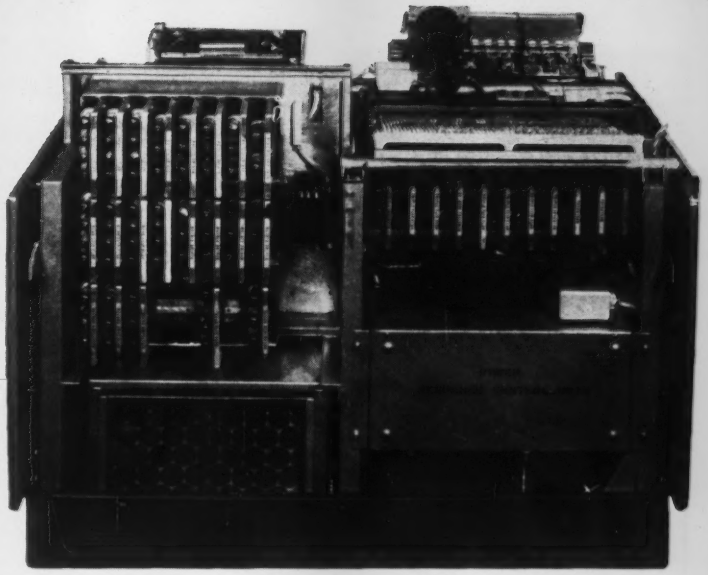
1. Recording, Storage, and Playback Techniques
2. Non-linear, Intermittent, and Automatic Scaling Procedures
3. Tricks of the Trade in Simulation
4. Stability of Components
5. When Is Linearization Permissible?
6. Statistical Techniques in Simulation
7. Use of Analog Techniques in Evaluation of Flight-test Data; i.e. Post-flight Simulation
8. What Does the Future Hold for Analog Computers?
9. Use of Perturbation and Other Techniques for Extending Analog Accuracy
10. Problems We'd Like to See Solved or Devices We'd Like to See Developed

These topics are listed here because if any reader should be in a position to give an informal talk on any of them I am sure that their local Simulation Council would like to hear from them. On the other hand, if anyone can offer a formal paper on these or allied subjects, your Ed. would positively like to hear from you because of the all-out effort the Simulation Councils Inc. are making to get a number of really worthwhile analog—or simulation by whatever means—papers on the program of the Western Joint Computer Conferences next May.

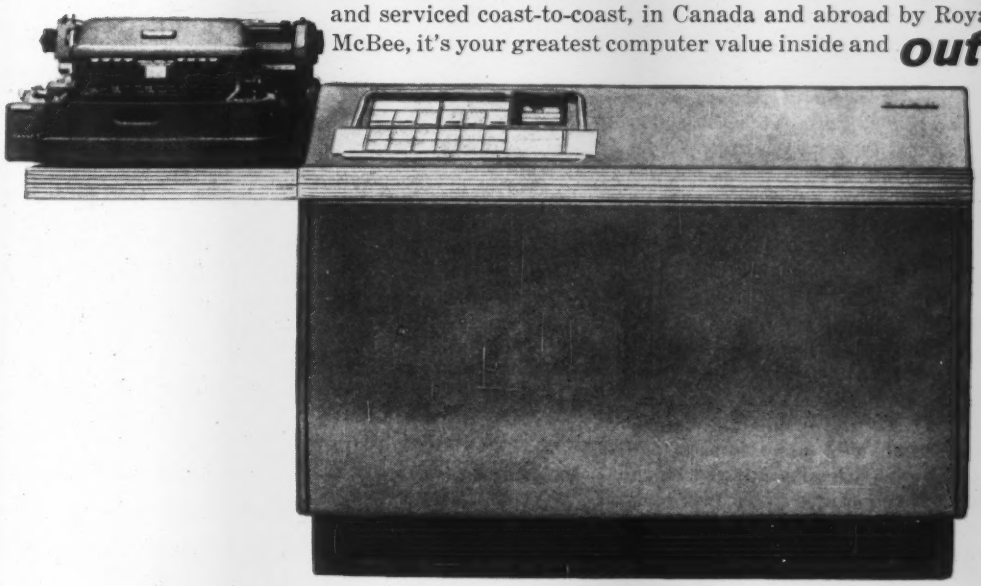
ROYAL PRECISION

LGP-30

Your greatest computer value on the market...



inside . . . The world's largest-selling engineering and scientific computer, the compact, mobile LGP-30 is also the lowest-priced complete computing system you can buy or lease. It gives you the largest memory (4096 words) and capacity in its class. Internal components have been greatly reduced to insure highest operating reliability. The logic circuit and few etched circuit cards are easily removed for checkout and maintenance. ***and*** . . . The LGP-30 operates from any wall outlet, requires no site preparation. With its simplified command structure, the LGP-30 is the easiest computer to program and operate. It is delivered complete with tape typewriter for alpha-numeric input-output. An extensive library of programs and sub-routines is available. Sold and serviced coast-to-coast, in Canada and abroad by Royal McBee, it's your greatest computer value inside and ***out.***



Royal Precision Corporation

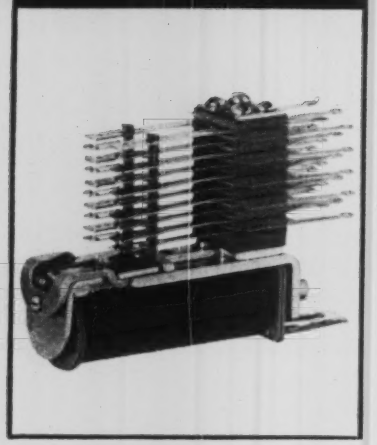
Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. LGP-30 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For complete information write **ROYAL McBEE CORPORATION,** data processing division, Port Chester, New York

CIRCLE 67 ON READER-SERVICE CARD

Stromberg-Carlson

"TELEPHONE QUALITY"

Relays



. . . featuring new high-voltage types for test equipment or other high-voltage applications.

THE insulation in the new relays withstands 1500 volts A.C.—3 times normal. These high-voltage models are available in Types A, B and E. They are the latest additions to the Stromberg-Carlson line of twin contact relays—all available for immediate delivery.

The following regular types are representative of our complete line:

Type A: *general-purpose relay with up to 20 Form "A" spring combinations. This relay is excellent for switching operations.*

Type B: *a gang-type relay with up to 60 Form "A" spring combinations.*

Type BB: *relay accommodates up to 100 Form "A" springs.*

Type C: *two relays on the same frame. A "must" where space is at a premium.*

Type E: *has the same characteristics as the Type A relay, plus universal mounting arrangement. Interchangeable with many other makes.*

Complete details and specifications are contained in our new relay catalog, available on request. Write Stromberg-Carlson Telecommunication Industrial Sales.

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A DIVISION OF **GENERAL DYNAMICS**
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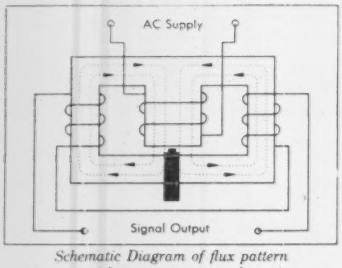
CIRCLE 68 ON READER-SERVICE CARD

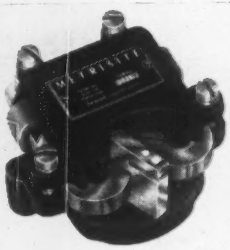
new instruments

FOR FURTHER INFORMATION USE THE FREE ORDER CARD ON PAGE 1597

MOTION TRANSDUCER



Schematic Diagram of flux pattern with armature centered.



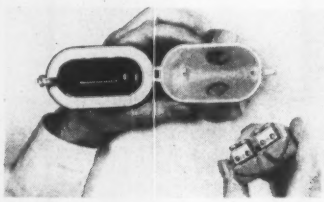
New Metrisite Motion-Sensing Device has performance characteristics "several orders of magnitude greater than any other transducer or control device available today." Resolution is such that measurements as small as one ten-millionth of an inch (one-tenth of a microinch) can be made. Light operating force will activate the moving element. Linearity of 0.1% due to the absence of hysteresis losses. Electrical output is of such a magnitude that the Metrisite can provide full-scale operation of a sensitive rectified-type meter directly without amplifier; outputs as high as 100 v. Employs a "B"-shaped magnetic core with an electrical coil around each of the three cross members. The center cross member has air gap in which a small movable copper slug moves. When an a-c input energizes the center primary coil, a magnetic field is set up in both loops of the core, which in turn induces a voltage in each of the two outer secondary coils. With the copper slug at dead center, the magnetic fields are symmetrical and the induced voltages in the secondary coils are equal. Slightest movement of the slug off center produces an unbalance of the two magnetic fields, which results in an electrical output signal caused by the difference in voltage in the two secondary coils.—*Brush Instruments, 37 & Perkins, Cleveland 14, Ohio.*

CIRCLE 164 ON READER-SERVICE CARD

THERMOCOUPLE HEAD

New Thermocouple Head assembly with a flip-top cap has a ceramic block which takes wires from 8 gauge down to the smallest sizes, and with a simple modification can be used with other types of standard thermocouple heads.—*Pyrometer Co. of America, Inc., Penndel, Penna.*

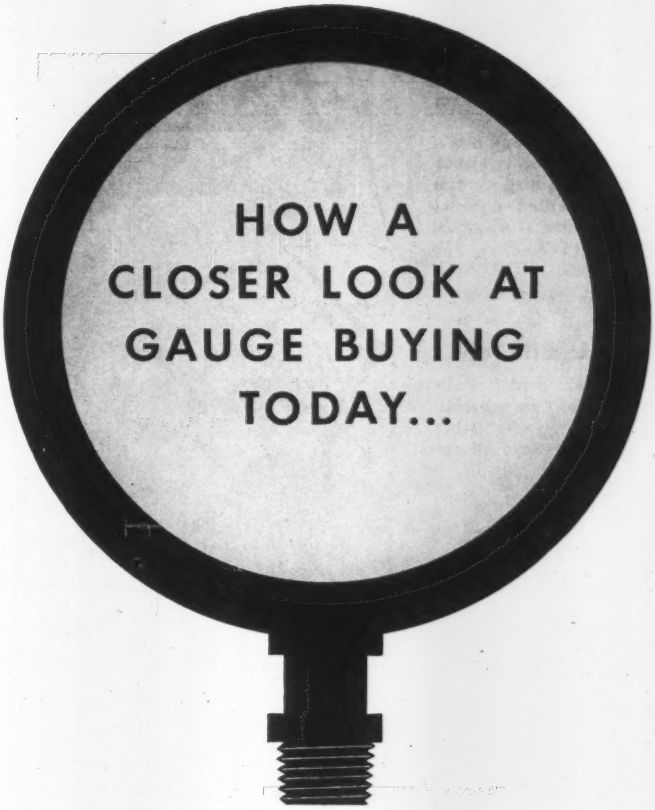
CIRCLE 165 ON READER-SERVICE CARD



THERMISTOR BRIDGE

CIRCLE 166 ON READER-SERVICE CARD

New Thermistor Bridge, Model TB-2, has accuracy of 0.1% of substituted power (50 times more accurate than power meters specified to be accurate to 5% of full scale in substituted power). Designed for use in calibration of output of signal generators at 1.000 milliwatts.—*Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.*

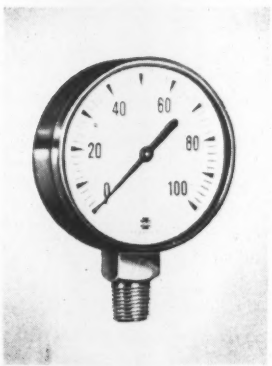


can give you a tighter grip on gauge costs!

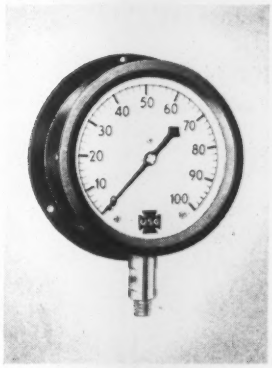
Been looking at gauge buying in your plant as "routine"? In terms of gauge performance you need, accuracy you get, price you pay . . . and how and where you buy? You can pick up real savings with a closer look at your gauge requirements . . . and at what United States Gauge offers. USG features the world's largest stock of indicating dial pressure gauges. Over 50,000 standards, plus specials, with all possible choices of sizes, case stylings, pressure ranges and case materials . . . up to and including the finest gauges of highest accuracy. One source meets 99% of your pressure gauge needs, with the exact gauge for the exact purpose at the right price. And one phone call to your USG distributor taps that source. See the Yellow Pages, or write for catalogs and name of your nearest USG distributor today.

UNITED STATES GAUGE

Division of American Machine and Metals, Inc., Sellersville, Pa.

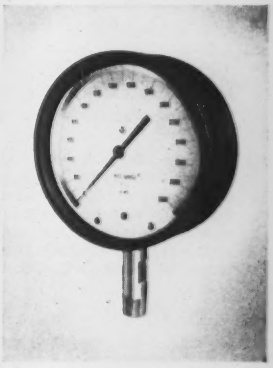


Replacement costs too high? Volume - priced, precision - built USG drawn-case gauges are the money-savers for replacement of any A.S.A. Grade B gauge in your plant (accuracy of 2% guaranteed). These standbys are specified by more than 60% of original equipment manufacturers today. Proof of USG reliability and value! *Write for Catalog 64A.*



Paying a premium for quality design, reliability? Check the new USG A-Line, premium design at savings up to 40% of premium prices! Meets A.S.A. Grade A Standards, including accuracy of 1%. Wide range of cases, sizes, movements, pressures cuts *you* in on A-Line savings wherever you need dependable gauge performance. *Write for Catalog 305.*

Paying for performance you don't get? Look at the USG Supergauge® line. Built like a watch to A.S.A. specifications for Grade AA Test Gauges, these gauges pay for themselves in long-lived, dependable performance and lower maintenance costs. Accurate to 0.5% of scale range. Full selection of case styles, sizes and options. *Write for Catalog 1819.*



Losing out on highest accuracy? USG Test Gauges are the elite of the industry, equalling or exceeding A.S.A. Grade AA standards with accuracy as high as 0.2 of 1%! Styles, sizes and case materials for all types of laboratory and test uses. You can't buy higher quality and precision in a test gauge! Get your money's worth at USG. *Write for Catalog 400.*

CIRCLE 69 ON READER-SERVICE CARD

VARIAN
Potentiometer
RECORDERS

Used by the thousands

because . . .

1. THEY ARE TRULY

PORTABLE

The Varian G-11A weighs only 15 pounds and can be carried anywhere in the laboratory, plant or field. And because it is a potentiometer recorder, it is highly sensitive and can be adapted to extremely varied recording requirements.

Varian recorder prices from $365; full-scale balancing time 1 or 2½ seconds; ranges from 0-9 millivolts to 0-100 volts, wide choice of speeds, accessories and charts. Full specifications and description available by writing the Instrument Division.

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CIRCLE 71 ON READER-SERVICE CARD

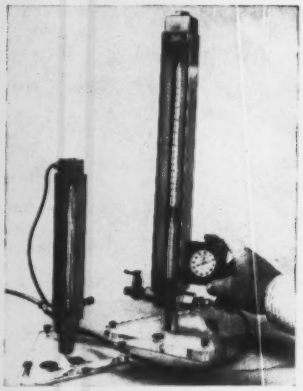
DUAL-BEAM OSCILLOSCOPE

New Model 411 Oscilloscope is "only true dual-beam oscilloscope." One gun can be used as a single beam oscilloscope having identical amplifiers, each amplifier having one millivolt full-scale sensitivity, while either the X- or Y-input of this display can be simultaneously presented against time on the other channel.—*Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N. J.*

CIRCLE 172 ON READER-SERVICE CARD

FLOW RATE CALIBRATOR

New portable, bench model Flow Rate Calibrator is designed especially for checking rotameters or other flow devices with inert gases in the

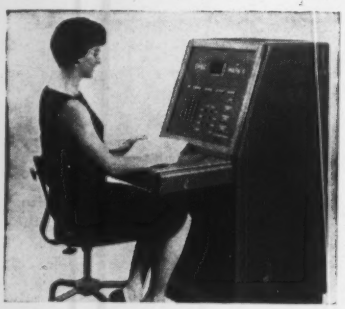


range of 1 to 5000 cc/min. Is a dry-seal, volumetric-type gas collecting unit utilizing a patented, frictionless mercury "O"-ring seal between a piston and precision-bore glass tube. Details in Specification Sheet SS-903. —*Brooks Rotameter Co., P. O. Box 432, Lansdale, Penna.*

CIRCLE 173 ON READER-SERVICE CARD

EDUCATIONAL COMPUTER

New Spec, a general-purpose stored-program digital Computer and digital differential analyzer (DDA) is completely modularized and com-



pletely transistorized and utilizes high-speed digital circuitry. All internal logical interconnections between the plug-in modules are effected via a removable plugboard patch pan-

This is the New

TALLY

Bi-directional
Paper Tape Reader

It reads paper tape rapidly and economically

Tally Series 424 Paper Tape Readers furnish a new low cost approach to rapid search and accurate punched paper tape reading. Self contained, this unique bi-directional asynchronous reader is available in both rack and console styles.

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A reading rate of 60 characters per second in either direction – instantly reversible. Triggered tape feed readout. Full accountability with form C switch providing positive hole/space identification. Reads 5, 6, 7, or 8 channels without modification. Low cost, only $595 for console unit. Can be slaved to any other 60 character device.

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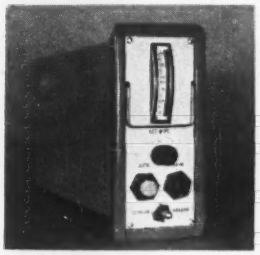
CIRCLE 74 ON READER-SERVICE CARD

el. By replacing the GPC (general-purpose computer) patch panel with the DDA panel, it is coverted into a digital differential analyzer containing 20 integrators. 14-page Catalog S1 gives details.—*Computer Control Co., Inc., 2251 Barry Ave., Los Angeles, Calif.*

CIRCLE 174 ON READER-SERVICE CARD

SOLID-STATE CONTROL SYSTEMS

New solid-state electric control components and systems use a transmission signal of −25 to +25v dc,



compatible with present data handling and performance monitoring equipment. Details in Product Specification E74-1.—*Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.*

CIRCLE 175 ON READER-SERVICE CARD

SQUARE ROOT INTEGRATOR-COMPUTER

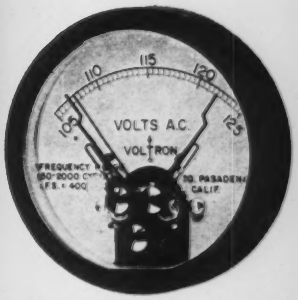
New panel-mounted Square Root Integrator-Computer C3A/1 is for use in flow measuring systems requiring a digital readout of totalized flow. Is intended primarily for use in Swartwout AutroniC(R) control systems. Installed in parallel with an AutroniC flow indicator, recorder and/or controller, it operates from a common 0-0.5 vac signal and has no effect on the control loop. The square root is extracted by inter-posing a flyball governor in the feedback loop from the servo motor to the servo amplifier. The flyball governor, rotated by the servo motor, exerts a force proportional to the square of its speed. Digital totalization is continuous and accurate from one to 100% of the input signal. Data are supplied in Specification Sheet No. A-807.—*The Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.*

CIRCLE 176 ON READER-SERVICE CARD

IF THE CARD HAS ALREADY BEEN USED, MARK NUMBER AND DATE OF ISSUE ON POSTAL CARD AND SEND C/O OUR READER SERVICE DEPT.

api + VOLTRON

ADDS UP TO 4-10 TIMES GREATER ACCURACY



EXPANDED SCALE METER-RELAYS

Voltron and API combine the best features of their two top instruments . . . the resulting expanded scale Meter-Relays can monitor and control any electrical variable that is measurable. These instruments are now the most accurate and reliable Meter-Relays available.

- 10,000,000 make-break cycles, with 100% perfect contact
- Low current and voltage inputs required
- Eliminates problem of load isolation in measuring circuits
- Available in 2½", 3½" and 4½" models

Many more advantages — get complete data from either firm . . .

See them at Wescon — API Booth 3101 — Voltron Booth 3417

api
Assembly Products, Inc.
Chesterland, Ohio

VOLTRON
VOLTRON PRODUCTS
1010 Mission St.
S. Pasadena, California

CIRCLE 77 ON READER-SERVICE CARD

WHEN YOU HAVE
extraneous common mode signals

AND WANT TO MEASURE
0.1 to 100 millivolts full scale

AND THEN AMPLIFY

CHOOSE THE NEW HONEYWELL D-C AMPLIFIER

AccuData II

wide-band differential all-transistor D-C Amplifier for strain gages and thermocouples

- **Full Scale Input:** Unbalanced: ±100 μv to ±100 mv Differential: ±3 mv to ±100 mv Open Loop: Below drift level
- **Full Scale Output:** ±2v at 50 ma, dc to 10 kc
- **Frequency Response:** to 20 kc
- **Output Impedance:** Less than 0.5 ohm at dc on all ranges
- **Input Impedance:** Unbalanced 3 to 100 mv ranges; greater than 20 megohms in parallel with 350 micromicrofarads. Differential: Greater than ± 2 megohms
- **Equivalent D-C Input Drift:** Less than 2 μv/10°F ambient temp change on 0.1 to 30 mv input ranges
- **Equivalent Input Noise:** 4μv peak-to-peak on 100 μv to 300 μv range (0-10 cps). 8μv rms on 10 to 30 mv ranges (0 to 100 kc)
- **Common Mode Rejection:** 200,000 at 60 cps on 3 to 30mv ranges

The new Honeywell AccuData II is a completely transistorized D-C Amplifier designed for use in high accuracy data handling systems as a wide-band pre-amplifier for strain gages and thermocouples. Its output can be fed to electronic or electromechanical analog-to-digital converters and simultaneously recorded on galvanometer oscillographs or magnetic tape. Either differential or single-ended input modes can be selected by an eleven position range switch. This switch changes the gain in three-to-one steps. Intermediate gains with high resolution are provided by a ten-turn potentiometer. Write for AccuData II Bulletin to Minneapolis-Honeywell, Dept. 50, Boston Division, 40 Life Street, Boston 35, Mass.

Honeywell

H HONEYWELL *First in Control*

CIRCLE 78 ON READER-SERVICE CARD

TEST CHAMBER

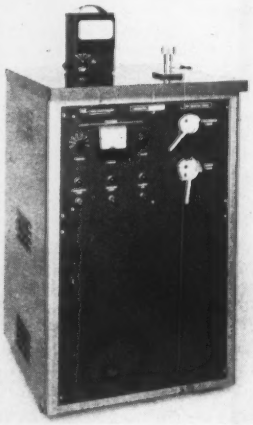
New Tenney-3 is smaller-space temperature Environmental Chamber with characteristics usually reserved for bigger models. Is a three-cubic-foot, front-opening upright chamber to which relative humidity can be

added at the buyer's option. Heretofore the 10-cu-ft Tenney-10 was the smallest model available with humidity option. Features include: Temperatures down to −120°F, and up to +350°F. Options include relative humidity of 20% to 95% in the dry bulb range of 35° to 185°F.—*Tenney Engineering, Inc., Union N. J.*

CIRCLE 177 ON READER-SERVICE CARD

ARGON LEAK DETECTION

New V.I.C. Argon Differential-Sorption Leak Test Station is "first really low cost complete facility for fast detection and pin-pointing of leaks." Has high sensitivity, compar-



able to that of the mass-spectrometer-type detector, and can be used for the same general application with lower investment. Uses inert argon gas, as well as helium, which is in short supply and often restricted entirely. The sensing element detects all inert gases without machine modifications or adjustments.—*Vacuum Instrument Corp., Huntington Sta., N. Y.*

CIRCLE 178 ON READER-SERVICE CARD

NO TEMPERATURE OVERSHOOT

WHEN SIMPLYTROL MINDS THE POT

time-proportioning controller has unique anticipating action

Low-cost Simplytrol gives you high-accuracy temperature control . . . effectively maintains temperature to within ± 1°F. of set point on most applications. An ingenious anticipating circuit eliminates overshoot difficulties by shutting off heat input at a time-proportioned interval before the set-point temperature level is attained.

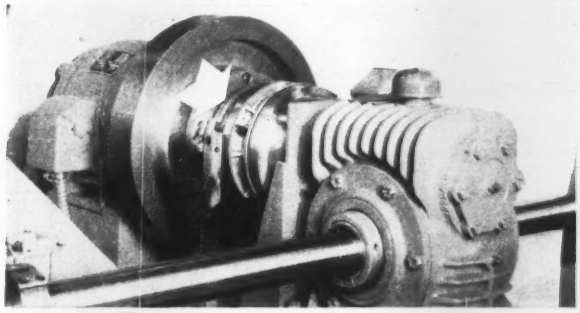
Built around the well-proven A.P.I. meter-relay design, Simplytrol uses no amplifying circuits or vacuum tubes; it is exceptionally stable and reliable. The unit is available in thirty ranges from —400°F. to +3000°F., is packaged in a newly re-styled table-mounting case that converts in minutes to panel mounting.

SEND FOR DATA SHEET 9-B

ASSEMBLY PRODUCTS, INC.

S.A., 1913

CIRCLE 79 ON READER-SERVICE CARD



Simplatrol ELECTRIC CLUTCHES & BRAKES

. . . Assure Super Clean Cutting Action In High Speed Power Shear

This is a Simplatrol C-B 160 Electric Clutch & Brake unit 6½" diameter at work in a high speed power shear.

Here the swift, quiet, durable Simplatrol Clutch and Brake unit mounted between the main motor drive and gear reducer gives clean cutting action; up to 70 strokes in an operating minute. Energized clutch moves the blade and rugged brake stops it, following single stroke cutting action.

Simplatrol Clutches and Brakes do their job silently . . . eliminate the constant noise usually associated with clutching and braking. Simplicity is keynoted in the patented diaphragm . . . the only moving part in the Simplatrol Clutch and Brake.

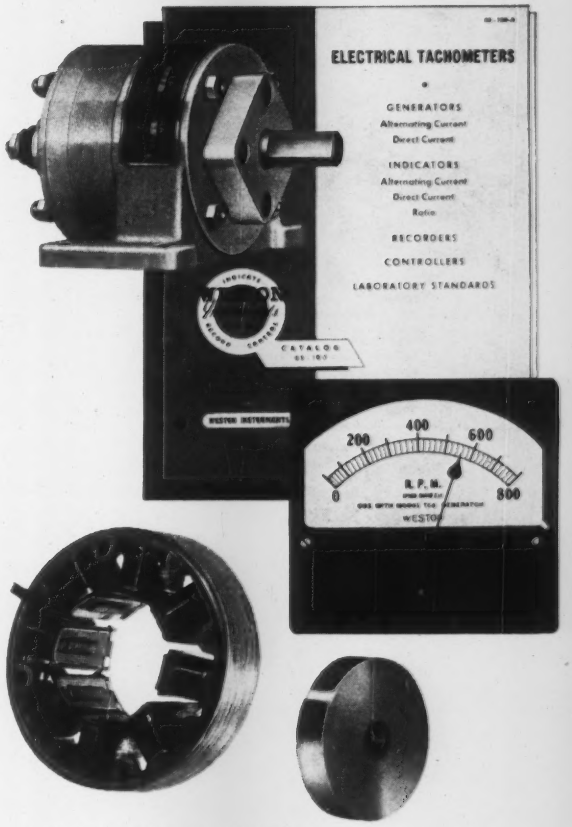
Ask for complete Simplatrol literature.

Simplatrol products corp.

24-8 SALISBURY ST., WORCESTER, MASS.
Representation in Key Industrial Areas

117-9

CIRCLE 80 ON READER-SERVICE CARD



The Weston Catalog:

YOUR BEST "TACHS-ADVISER"

One look and you see why Weston Electrical Tachometers are a sound investment. Unequalled for simplicity of design, flexibility of application and reliability even under adverse conditions, this broad line of accurate, rugged, maintenance-free instruments can be fitted to existing or original equipment with equal ease.

For indicating, recording or controlling functions, in any combination . . . for measuring speed, speed ratio or speed differential, from 100 rpm to 100,000 rpm . . . for accuracies as high as ±1/10% . . . you'll find your best answer in Weston Catalog 03-100.

This catalog reveals full details of available units including A-C and D-C generators, self-contained and bearingless; variety of mountings; voltage-responsive and frequency-responsive networks; indicators, recorders, recorder-controllers and accessories.

For your copy, or for information about engineering assistance, get in touch with your local Weston representative, or write:

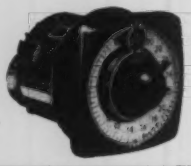
Daystrom-Weston Sales Division, Newark 12, N. J.
In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.

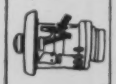
WESTON *Instruments*

A DAYSTROM UNIT

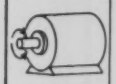
World Leader in Measurement and Control

CIRCLE 81 ON READER-SERVICE CARD

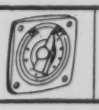




SERIES 305—Controls up to 6 individual load circuits; easily changed from "Reset" to "Non-Reset."



SERIES 306—Controls 2 separate adjustable load circuits; built-in dwell protects reversing motors.



SERIES 304—Percentage Timer; integral "On-Off" control eliminates separate switch.

SERIES 307—Revolution Counter; permits direct connection to flexible cables, differential couplings, gears, rotating shafts.

TIMERS FOR AUTOMATIC CONTROL

SPLIT SECONDS OR HOURS ACCURATE...RUGGED

Now you can order off-the-shelf timers for every industrial control application, including highly complex control functions involving hundreds of timed or sequential operations. ATC offers the widest line of standard timers, plus complete design and engineering assistance to meet special requirements. These unique features mean more dollar value from ATC timers:

Easy one-hole mounting in standard 3 3/16" cut-out. **Fully insulated ring clamp replaces screws.**

Change cycle any time with handy large knob. **Cover slips off without disconnecting timer from service.** **One piece rolled cover has integral printed wiring schematic.**

Write now for new illustrated Condensed Catalog; contains complete specifications and performance data.

atc

AUTOMATIC TIMING & CONTROLS, INC.

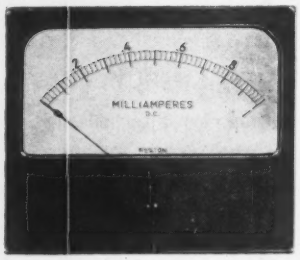
KING OF PRUSSIA, PENNSYLVANIA

A SUBSIDIARY OF SAFETY INDUSTRIES, INC.

CIRCLE 82 ON READER-SERVICE CARD

4.5" PANEL INSTRUMENTS

New Models 1751 (D-C) and 1752 (A-C) rectangular-shaped 4.5" Panel Instruments are designed for mounting to ASA C39.1-1955 specifications. Features: molded bakelite bases and covers with glass windows, lance-type pointers, 4-inch, 100°-arc scales, and

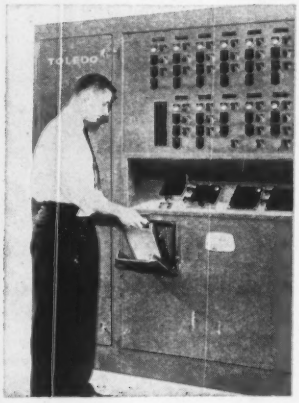


the Weston Cormag self-shielding mechanism which permits instrument mountings in close proximity on magnetic or non-magnetic panels. Available as ammeters, milliammeters, microammeters, and voltmeters (1000 ohms per volt) with 2% accuracy (d-c) and 3% (a-c). Many ranges.—*Daystrom-Weston Sales Div., Daystrom Inc., 614 Frelinghuysen Ave., Newark 12, N. J.*

CIRCLE 179 ON READER-SERVICE CARD

BATCHBOARD CONTROL

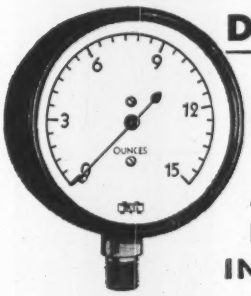
New method for Automatic Batching Control, "Batchboard" Remocon control, affords proportioning control opportunities through automatic presetting of unlimited numbers of batch formulas from a central re-



mote location. Each "Batchboard" is approximately 7" x 10" x 2" and contains contact holes, each representing a weight value. An individual "Batchboard" is used for each formula, and once the unit is wired, it can be used indefinitely without rewiring. As many as 20 ingredients can be controlled by one "batchboard".—*Toledo Scale Corp., Toledo 13, Ohio.*

CIRCLE 180 ON READER-SERVICE CARD

MARSHALLTOWN



DIAPHRAGM GAUGE

FOR ACCURATE PRESSURE MEASUREMENT IN OUNCES OR INCHES OF WATER

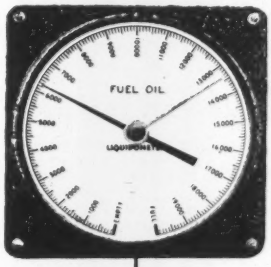
Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" -0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

Write for details and price. LOOK TO MARSHALLTOWN FOR ONE OE THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

CIRCLE 83 ON READER-SERVICE CARD

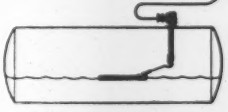


100% AUTOMATIC TANK GAUGING

Dependable remote reading tank contents gauges using a closed hydraulic transmission system. No power required.

Several sizes available. Approved by Underwriters Laboratories and Factory Mutual. UL approved switches.

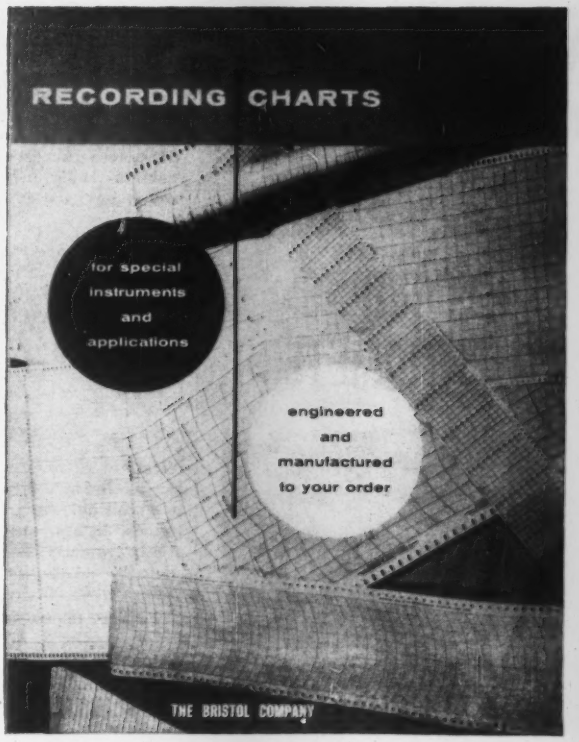
Write for complete details, to Dept. **E**



Since 1920 LIQUIDOMETER INSTRUMENTS of proven quality

THE LIQUIDOMETER CORP.
LONG ISLAND CITY 1, NEW YORK

CIRCLE 84 ON READER-SERVICE CARD


RECORDING CHARTS
for special instruments and applications
engineered and manufactured to your order
THE BRISTOL COMPANY

new bulletin answers

chart problems

for new instrument designers

The new Bulletin Y1906 tells the story of Bristol's special chart designing and printing service.

It will help you with your new chart design and it will also give you some idea of the thoroughness with which Bristol is prepared to consider every aspect of instrument chart production from engineering to final printing. Naturally, as a special chart customer, you get the benefit of our 70 years of experience in designing and printing charts of all kinds for our own Bristol instruments as well as hundreds of instrument builders.

Strip charts up to 29⅛" across, circular charts to 12" diameter can be handled in Bristol's recently expanded chart pressroom. Highest quality standard chart papers are used, or "specials" like: papers for metallic marking, foil-type laminates, card stock, or heat and pressure-sensitive, carbon-coated, or photo-sensitive oscillographic papers.

Write us today for the complete Bristol chart story. Just ask for Bulletin Y1906. The Bristol Company, 154 Bristol Road, Waterbury 20, Conn. B-46

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

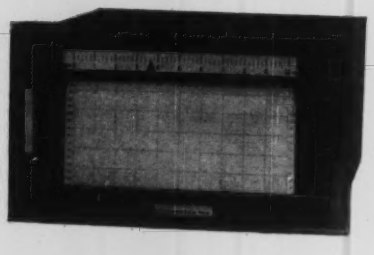
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

CIRCLE 85 ON READER-SERVICE CARD

Where there's no margin for error...

westronics

RECORDING POTENTIOMETERS



11" CHART AVAILABLE WITH ONE or TWO PENS RECORDING FULL SCALE

FEATURING

SMALL SIZE

- Only 60% the size of old line instruments
- Designed for standard relay rack mounting

VERSATILITY

- Minimum span—1 MV
- Plug in range, MV or TC
- Chart drives, synchronous and/or selsyn, with large selection of speeds
- Marker pens, L and/or R
- Limit switches
- Transmitting slidewires

Also available: One and two pen 5" recorders

wi westronics® INCORPORATED

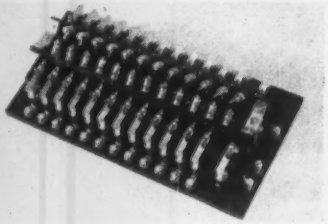
3605 McCART STREET • FORT WORTH, TEXAS

CIRCLE 86 ON READER-SERVICE CARD

NEW INSTRUMENTS

A-C RELAYS

New 25-amp mechanically-held A-C Relays are now available with up to 24 poles. Increased number of poles permits wide utilization as primary relay devices controlling contactors,

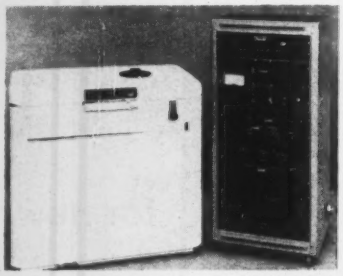


solenoid valves and similar equipment, or as branch circuit devices directly controlling electric ovens and furnaces, lights, and other loads within their capacity. Bulletin 1255-166 gives details.—*Automatic Switch Co., Florham Park, N. J.*

CIRCLE 181 ON READER-SERVICE CARD

LIQUID SCINTILLATION COUNTER

New low-cost semiautomatic Liquid Scintillation Counter LSC-10 performs precision analysis of low-energy beta emitters (i.e. C^{14} and



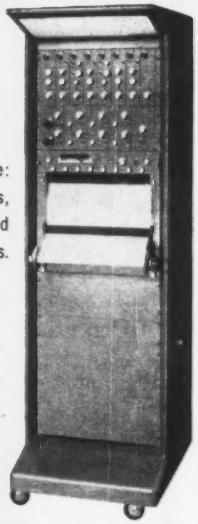
H^3). Consists of a compact top-opening deep freeze unit which contains the semiautomatic sample changing equipment, and a four-foot instrument console containing the associated electronic circuitry. The sample changer holds forty 20 ml glass sample vials. Bulletin No. 101 gives details.—*Tracerlab*, 1601 *Trapelo Rd., Waltham* 54, *Mass.*

CIRCLE 182 ON READER-SERVICE CARD

RELAY CONTROL AMPLIFIER

New compact relay control amplifier has a sensitivity of one μv and stability of $\pm$ one μv. Adapts to any type of control instrumentation where the transducer generates a change in voltage or resistance that is representative of the measured variable, including, "go/no-go" quality control system. Amplifier is a high-gain d-c-to-a-c amplifier which recognizes the polarity of a low-level d-c input sig-

OFFNER All Transistor

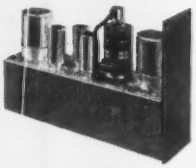


Models available: 1 to 19 channels, console, rack, and portable assemblies.

TYPE R DYNOGRAPH

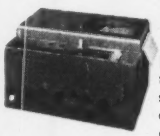
A direct-writing oscillograph with unmatched features of superiority! Whatever your application for direct-writing recording, the Offner Type R All Transistor Dynograph will do your job *better* and more *easily*. Write on your letterhead for literature and complete specifications.

TYPE 190 *Differential* DATA AMPLIFIER



Zero-drift d-c amplifier with 1/100% accuracy. Linearity of better than 0.05%. Gain stability of 0.01%. Ripple of less than 0.1%. Infinite rejection of common d-c signals. Rapid response to step input. Ambient range −67°F to 170°F. Ask for Bulletin 572.

Type 542 Two-Channel DYNOGRAPH



Rapid response, high sensitivity, stability, compact construction, economical price—all features that make this all transistor, 2 channel unit ideal as a test instrument . . . practical for use at every laboratory bench. Ask for Bulletin 181.

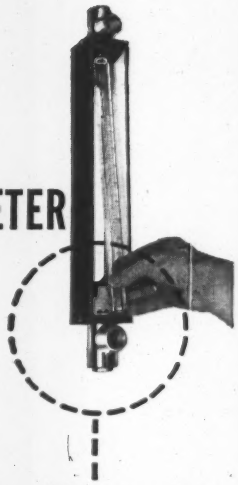
OFFNER ELECTRONICS

3910 River Road, Schiller Park, Ill.

(Suburb of Chicago)

CIRCLE 87 ON READER-SERVICE CARD

NEW FULL-VIEW® ROTAMETER



Interchangeable metering tubes snap in and out . . . in seconds! It's that easy to change range or to service the new Brooks Series 1112 Full-View Rotameters.

A stainless steel leaf spring (entirely isolated from the process fluid) holds the tube perfectly in position, yet allows removal with just a simple up-and-out movement. No tools necessary.

Special O-ring construction and tube adapter assemblies make this time-saving convenience possible. Up to four different size metering tubes may be interchanged in a single case by merely changing adapters.

Like all Full-View Rotameters, the new Series 1112 features Brooks' dowel-pin, side-plate case construction. Thoroughly proven in service, this practical construction gives the meter case rigid strength, protects the glass metering tube from all line strain.

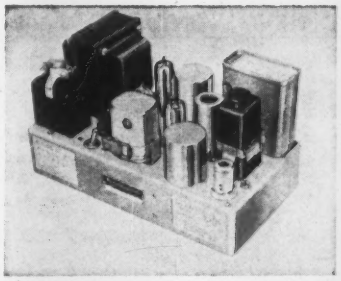
For More Information, Request Design Specification Sheet SS-111-2

BROOKS ROTAMETER COMPANY

1059 J STREET, LANSDALE, PA.

S.A. 1937

CIRCLE 88 ON READER-SERVICE CARD

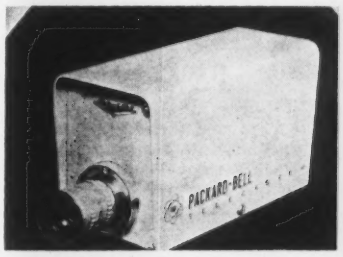


nal, converts it to a-c, and amplifies it to a signal with sufficient strength to actuate its master relay in accordance with that polarity. Operating power supply is 115 v, ±10; 50 to 60 cps. Amplifier weight 6.5 lb.—*Thermo Electric Co., Inc., Saddle Brook, N. J.*

CIRCLE 183 ON READER-SERVICE CARD

ITV

New closed-circuit Television Camera provides detail in excess of 600-line resolution, has single operating control, automatic light com-

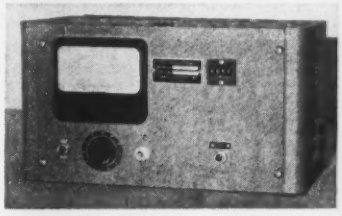


pensator. Remote accessories: pan and tilt unit, auto-zoom lens, remote control turrets, and an air conditioned weatherproof housing with windshield wiper.—*Packard Bell Service Div., 1920 S. Figueroa St., Los Angeles 15, Calif.*

CIRCLE 184 ON READER-SERVICE CARD

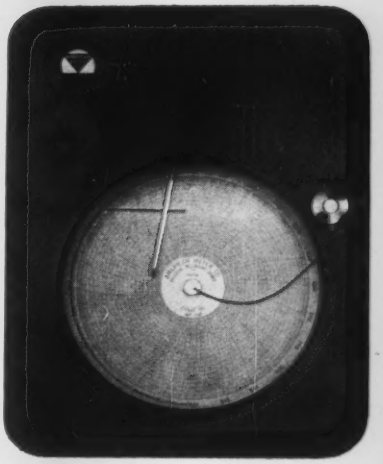
WIRE FAULT RELAY

New "Wire Sparker" a low-cost electronic Fault Relay, has a-c or d-c output. Features: speeds up to 2000 ft/min. with 5" electrode, (400



fpm per 1" of electrode); suitable for extruder or respooler use. Provides fast, accurate indication of faults, even at very low output voltages, (a typical 14 kv d-c Sparker will work at 700 v.—*Peschel Electronics, Inc., RFD #1, Patterson, N. Y.*

CIRCLE 185 ON READER-SERVICE CARD



AMERICAN®

PRESSURE and TEMPERATURE RECORDERS

American® single and two-pen *Pressure Recorders* for pressures from 30 inches vacuum to 10,000 psi.

- Pressure elements individually calibrated over full range.
- Variety of chart drives available.
- Helical elements of different ranges are interchangeable.
- Stainless steel pen arms with span and linearity adjustments.
- Aluminum dust and moisture-proof case.

American® *Temperature Recorders* for an accurate record of flowing temperatures.

- No ambient temperature errors.
- High sensitivity and torque—fast speed of response.
- Standard 0-150°F. range. Other ranges available by request.
- 24-hour mechanical or 110-v. 60-cy. electric chart drives.

Ask for Bulletins 400 and 408

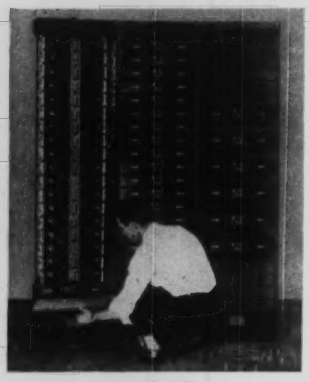
AMERICAN® METER COMPANY

INCORPORATED (ESTABLISHED 1836)

General Offices: Philadelphia 16, Pa.
Sales Offices in Principal Cities

CIRCLE 89 ON READER-SERVICE CARD

UP TO
37 CHANNELS
IN THE
Voice Band
(300 to 3000 CPS)



with Comvor®
DATA TRANSMISSION TERMINAL

RFL Model 912
Operates over Wire Circuit or Microwave

•

Reliable HIGH-SPEED Continuous Control
of
PUMPS
VALVES
MOTORS
GENERATORS
RELAYS
ETC.

The Model 912 Comvor, an audio frequency shift terminal, is used in the transmission of telemeter, telegraph or control signals over either wire line, microwave, or carrier. Up to 90 individual information channels are available in the audio spectrum.

Reliable frequency shift method of keying is used. All essential controls such as transmitter output level and receiver input level are included.

Each terminal contains its own power supply which provides an additional 60 milliamperes at both the transmitter and receiver for the operation of relays, stepping switches, selector magnets, and other components used in telemetering, control and telegraph applications.

WE CAN HELP YOU
Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DEerfield 4-3100.

Write for Technical and Application Data.

Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

CIRCLE 90 ON READER-SERVICE CARD

NEW INSTRUMENTS

VALVE TEST BENCH

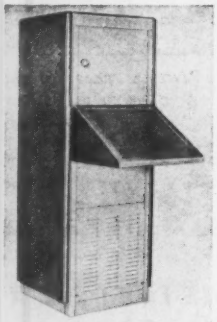
New Valve Test Bench is designed for pressure testing of all types of valves. Has two test plates: one for ½" thru 2" screwed valves and 8" thru 10" flanged valves, and one for

2½" thru 6" flanged valves. Two different valves may be tested at the same time, with either gas or liquid within a pressure range of 0 to 1000 psi on the standard valve test bench. —*Piping Engineering Co.*, 2010 *S. Utica, Tulsa, Okla.*

CIRCLE 186 ON READER-SERVICE CARD

RACKS

New F-Series line of Prem-O-Rak Modular Transmitter Racks is designed for multiple installations and for use with the Prem-O-Rak con-

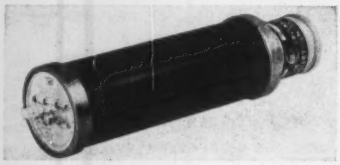


sole cabinets. Doors, end panels, flush doors, shelves and turrets are available as accessories for modular systems.—*Premier Metal Products*, 337 *Manida St., New York* 59, *N. Y.*

CIRCLE 187 ON READER-SERVICE CARD

SCINTILLATION DETECTOR

New Model D5-12 Scintillation Detector will drive up to 500 feet of cable without an auxiliary preamplifier or power source. Provides an integral transistor preamplifier circuit



MINIATURE MANIFOLDS
for
Multi-Purpose CONTROL

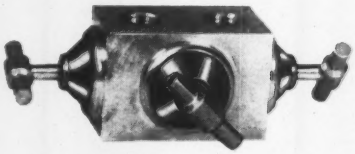


Photo ½ actual size

PACKLESS
"DEMI"
M2 SERIES

All models of the standard Dahl "Demi" M2 series of three-valve manifolds are readily adaptable to clean liquid, gas and vapor applications. The size of these manifolds makes them especially suitable for pilot plant, aircraft and marine applications, flow control and automation. They are miniature in size, yet their patented form for bubble-tight shutoff makes them comparable to much larger valves in performance.
These manifolds consist of two block valves and one bypass valve in place of 3 separate valves . . . they eliminate two tees, four nipples and eight threaded connections. Models of the "Demi" M2 series come in a variety of barstock materials and may be ordered with special features such as: bolted bonnets, swaged-in TEFLON seats, toggle actuators, etc.

PRESSURE RATING Metal Body & Diaphragm Neoprene Diaphragm	 750 psi at 450°F 100 psi at 180°F
MAXIMUM Cv	0.4
CONNECTIONS	1/16", 1/8", 1/4" N.P.T.

Send for the "DEMI" Catalog D-1 and other technical data on Dahl pneumatic and hydraulic valves.

GEORGE W.
DAHL
COMPANY, INC.
86 TUPELO STREET, BRISTOL, RHODE ISLAND

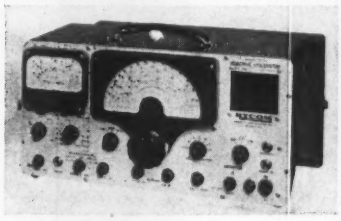
CIRCLE 91 ON READER-SERVICE CARD

which operates on a small part of the voltage supplied to the photomultiplier. Can be used with counting instruments that are not equipped for the connection of accessories such as the extra preamp.—Interchangeable aplha, beta and gamma detector crystals are available.—*Technical Measurement Corp., 441 Washington Ave., N. Haven, Conn.*

CIRCLE 188 ON READER-SERVICE CARD

FREQUENCY-SELECTIVE VOLTMETER

New Model 2174A Selective Voltmeter employs the heterodyne principle with balanced modulation. Makes amplitude measurements throughout the frequency spectrum of 300 cycles to 400 kc. Uses highly-selective crys-

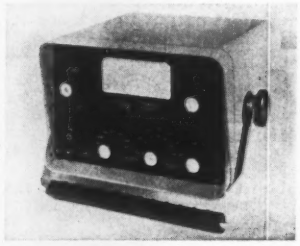


tal filters to achieve the resolution necessary for amplitude measurements of microwave subcarrier, wire line communications and subcarrier telemetering systems. Features include a gear-driven dial mechanism, a balanced input transformer with circuits provided for 135 ohm, 600 ohm or bridging inputs.—*Rycom Instruments, 9351 E. 59 St., Raytown 33, Mo.*

CIRCLE 189 ON READER-SERVICE CARD

TRANSISTORIZED VOLTMETER

New series Model R-3 Transistorized Voltmeter measures a-c voltage from 1 mv to 1000 v full scale in 14 ranges over a 10-cps to 200-kc frequency range; + and — d-c voltages from 1 v to 1000 v full scale in 7



ranges; electrometer input from 0 to 1 vdc and center-scale resistances from 10 ohms to 10 megohms in seven steps. Overall accuracy is now better than 3% on all voltage readings.—*Southwestern Industrial Electronics Co., 10201 Westheimer Rd., P. O. Box 13058, Houston 19, Texas.*

CIRCLE 190 ON READER-SERVICE CARD

lightest weight/easiest installation/silent no hum operation

NEW HOKE

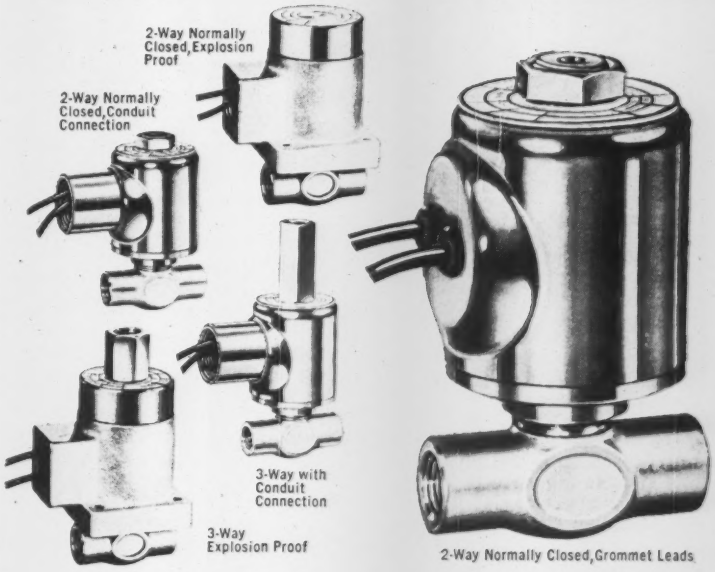
lowest temperature rise and power consumption

SOLENOID

stainless steel plunger design/silver ac shading coil

VALVES

smallest size/packless construction/operates any position


2-Way Normally Closed, Explosion Proof
2-Way Normally Closed, Conduit Connection
3-Way with Conduit Connection
3-Way Explosion Proof
2-Way Normally Closed, Grommet Leads

The lightest, smallest direct-acting solenoid valve available, featuring many innovations in design plus the usual, high-quality standards of all Hoke products. Two-way and three-way types (Series 90 and Series 95), with brass or stainless steel bodies are in production, in standard female connection sizes: ⅛" and ¼" as well as ¼" OD tube, 37° flare. Orifice sizes from 1/32" to ⅛". Mount in any position; a 360° rotatable coil housing permits connections from any angle. Choice of materials for valve discs and body gaskets. Variations in basic design to fit your needs. Competitively priced!

HOKE

Complete specifications, ordering information, etc., are included in bulletin No. SV-559. Send for your copy.

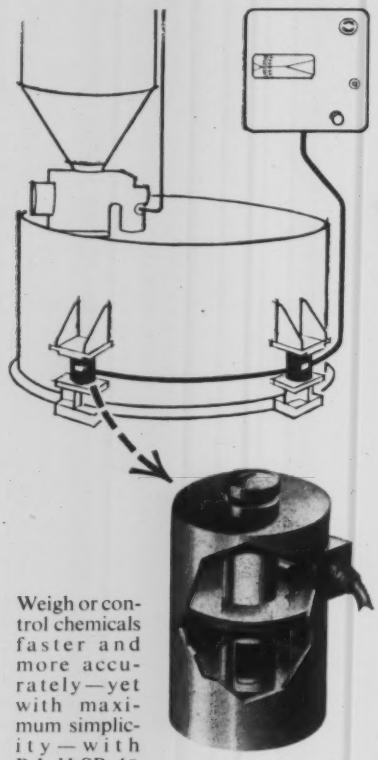
Fluid Control Specialists

HOKE INCORPORATED, 31 PIERMONT RD., CRESSKILL, N. J.

CIRCLE 92 ON READER-SERVICE CARD

MEASURING QUANTITY?

Then do it the modern way ... with accurate, rugged, trouble-free SR-4® Load Cells



Weigh or control chemicals faster and more accurately—yet with maximum simplicity—with B-L-H SR-4® Load Cells. Installed as part of the tank support structure, no part of the measuring system comes in contact with the contents of the tank. Can be installed on tanks already in use. Output suitable for use with local or remote indicator, recorder or automatic dispensing control. Explosion-proof. Hermetically sealed—unaffected by dust, grease or moisture; long-service life assured. Available in standard capacities of 50 through 200,000 lb., accuracies to ±0.10%.

For more information on load cells and complete batching systems, write Dept. 7-J and ask for Bulletins 4355 and 4510

FIRST in force measurement

SR-4 BALDWIN BLH LIMA-HAMILTON

BALDWIN-LIMA-HAMILTON

Electronics & Instrumentation Division
Waltham, Mass.
SR-4® Strain Gages • Transducers • Testing Machines

CIRCLE 93 ON READER-SERVICE CARD

NEW INSTRUMENTS

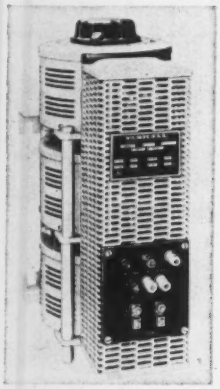
HIGH-TEMPERATURE PROBES

New series of resistance probes measures the temperature of non-corrosive gases or dry chemicals up to 800°F. Can also be inserted directly in rolls or platens. Resistance-temperature characteristics are similar to the MH series of RdF Stikons. Steel sheath provides mechanical protection. Custom high temperature probes available on special order.—*Arthur C. Ruge Associates, Inc., Hudson, N. H.*

CIRCLE 191 ON READER-SERVICE CARD

A-C/D-C POWER SUPPLY

New Varicell adjustable A-C/D-C Power Supply consists of a 3-phase, low-voltage Powerstat variable transformer combined with a static d-c power supply using silicon cells connected for 3-phase operation. Ripple



content is approximately 4.2% and ripple frequency 360 cycles at a supply frequency of 60 cycles. Input is 240, 3-phase (primary delta connected). A-c output can be either 0-30 v, 40 amp (secondary delta connected) or 0-50 v, 25 amp (secondary wye connected). D-c output can be either 0-35 v, 50 amp (secondary delta connected) or 0-60 v 30 amp (secondary wye connected). Regulation is approx. 10%. Details in Bulletin V359. —*Superior Electric Co., Dept. V4050, Bristol, Conn.*

CIRCLE 192 ON READER-SERVICE CARD

DIGITAL PRINTER

New high-speed Digital Printer, Model 3303, completely transistorized, features print-out rates in excess of 10 lines/sec and custom designed format with choice of number of columns up to 20 and type of characters or symbols. Storage and programming electronics are offered in a separate housing. Any character coding or single line control can be employed

Vi... solid state galvanometer driver amplifier

... especially designed to **"FILL THE GAP"** *between low power voltage sources and high frequency galvanometers requiring up to 100 milliamperes of driving power.*

Typical voltage sources are high gain DC amplifiers, telemetering receivers, demodulators, detectors, oscillators, transducer-demodulator combinations, etc.

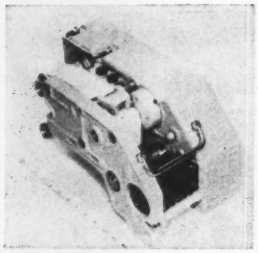
This unit, Model 92, is also useful as a programmed power supply. When connected to a reference cell (which is incapable of delivering sufficient current for many applications), it will faithfully reproduce the cell's voltage while delivering up to 100 milliamperes at at output impedance of less than one ohm.

Priced at $150.00 each (f.o.b. Santa Monica, California), the Model 92 provides the necessary galvo driving power at a very low cost to your instrumentation system.

Input	Single ended; isolated from case
Input Impedance	Greater than 100,000 ohms
Output	±10 volts at 100 ma.
Total Noise and Hum	Less than 3 mv peak to peak
Bandwidth	DC to 10 KC ±1 db.
DC Linearity	0.2%
Long Term Stability	When used with galvanometers having a maximum sensitivity of one inch per volt, drift and noise are not distinguishable on the record.
Power Requirements	115V ±20V, 50 cps to 400 cps, 8 watts maximum.

VIDEO INSTRUMENTS CO., INC.
3002 Pennsylvania Ave., Santa Monica, Calif.

CIRCLE 94 ON READER-SERVICE CARD



to control printer. Pressure-sensitive paper is used. Custom designs are available. Dimensions: 8½" x 8" x 15⅞", and 34 pounds in weight.—*Potter Instrument Co., Inc., Sunnyside Blvd., Plainview, L. I., N. Y.*

CIRCLE 193 ON READER-SERVICE CARD

ELAPSED TIME INDICATORS

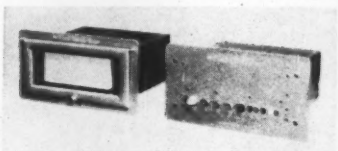
New line of sub-miniature hermetically-sealed Elapsed Time Indicators operate on 115-v 60-cps supplies (complementing earlier line of 400-cps units). Three basic models are offered. Digital model has 5 digits

reading to 9999.9 hours in tenth-hour increments. Two-dial type models are offered: one reading to 2500 hours in 5 hour increments and one reading to 10,000 hours in 10 hour increments. All models use a miniature 60-cycle motor drawing less than three watts. Details in Bulletin ET-603.—*A. W. Haydon Co., Waterbury, Conn.*

CIRCLE 194 ON READER-SERVICE CARD

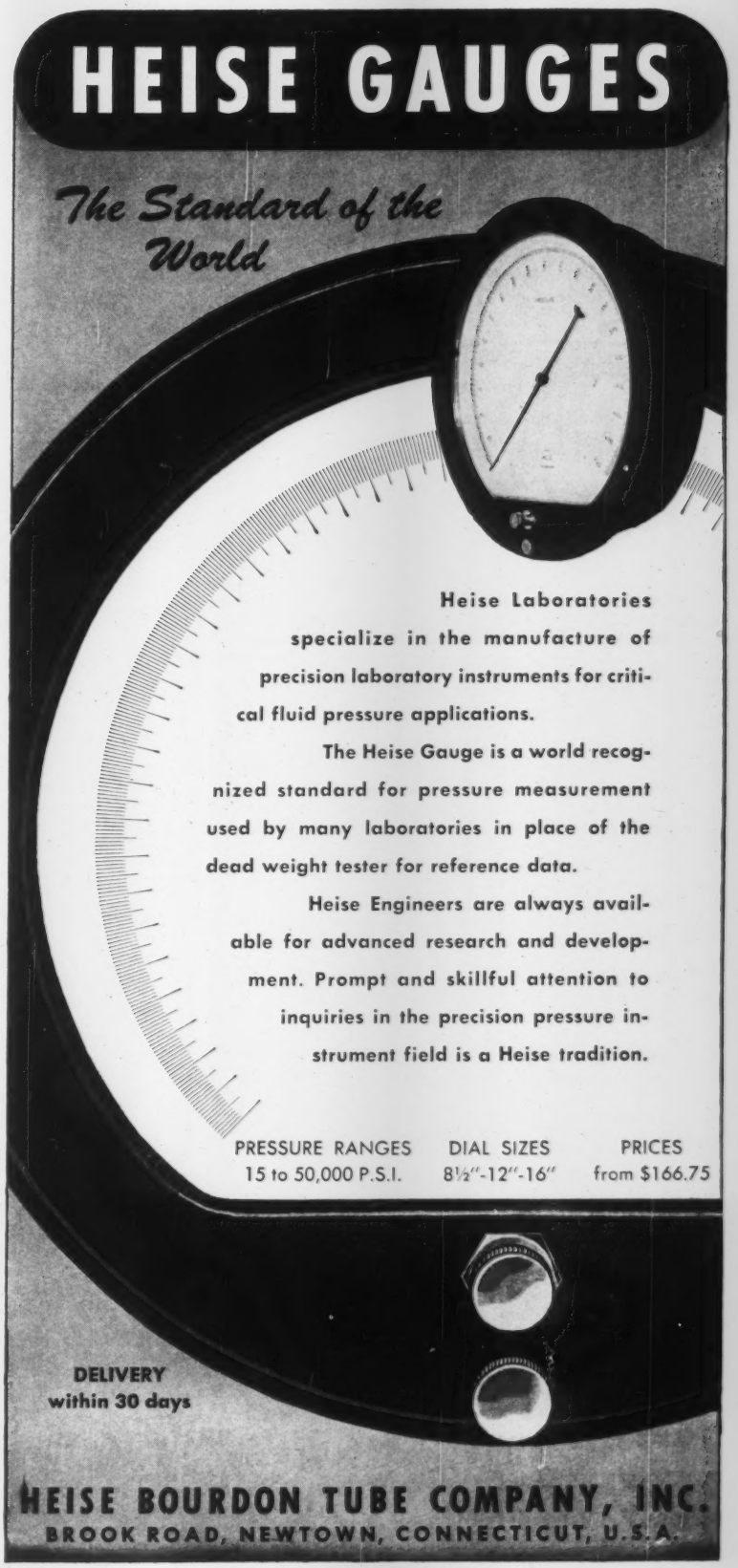
OPERATIONS RECORDER

New rugged Operations Recorder operates only on a change in the incoming signal in either the analog or digital channels. Features: 6 off-on channels and 1 analog (digitized) channel. Chart is 3¼" wide. Marking



is produced by fixed styli, each excited from its controller. Starting time is 19 msec to reach 63% of operating speed. Frequency response is 0-600 cps for the analog (digitized) channel and 0-200 cps on the off-on channels. Accuracy is ± 2.5% for analog channel, marked with fifty digits peak-to-peak at maximum deflection.—*The Hamilton Watch Co.*, 5800 *East Jewel Ave., Denver* 22, *Colo.*

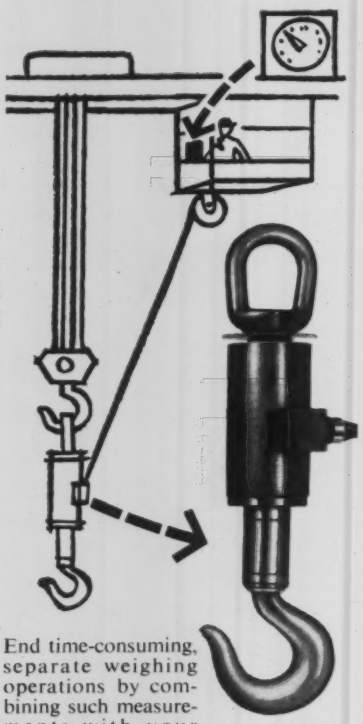
CIRCLE 195 ON READER-SERVICE CARD


HEISE GAUGES
The Standard of the World
Heise Laboratories specialize in the manufacture of precision laboratory instruments for critical fluid pressure applications.
The Heise Gauge is a world recognized standard for pressure measurement used by many laboratories in place of the dead weight tester for reference data.
Heise Engineers are always available for advanced research and development. Prompt and skillful attention to inquiries in the precision pressure instrument field is a Heise tradition.
PRESSURE RANGES
15 to 50,000 P.S.I.
DIAL SIZES
8½"-12"-16"
PRICES
from $166.75
DELIVERY
within 30 days
HEISE BOURDON TUBE COMPANY, INC.
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

CIRCLE 95 ON READER-SERVICE CARD

MEASURING WEIGHT?

Save handling time with easy-to-install, remote-indicating SR-4® Crane Scales



End time-consuming, separate weighing operations by combining such measurements with your normal materials handling program. SR-4® Crane Scales provide you with accurate inventory control information—on remote dial or printer type indicators—while materials are being moved. SR-4® Crane Scale sensing elements contain no moving parts; require no maintenance; and are unaffected by dirt, grease, water or corrosive fumes. Connection to indicator consists of only a light, flexible electrical cable. Accuracies guaranteed to ±0.2% of capacity. Available for immediate delivery in various capacities from ½ through 25 tons.

For 12-page Bulletin No. 4513 write Dept. 7J

FIRST in force measurement

SR-4 BALDWIN BLH LIMA-HAMILTON

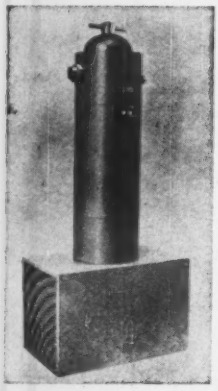
BALDWIN·LIMA·HAMILTON

Electronics & Instrumentation Division
Waltham, Mass.
SR-4® Strain Gages • Transducers • Testing Machines

CIRCLE 96 ON READER-SERVICE CARD

AIR DRYER

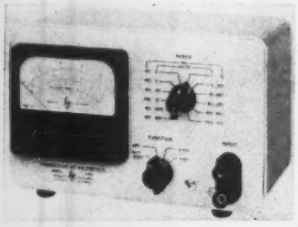
New Refrigifilter, a refrigerated unit to safeguard pneumatically-operated equipment from all forms of moisture, oil, and contaminants (especially designed for locations where cooling water is unavailable or where the ambient day-night temperatures vary a great deal) lowers the dew point of compressed air to approximately 35°F at pressure, thus condensing out over 90% of all moisture/oil vapors and removing all entrained liquids. Rated 100 scfm at 100 psig and 100°F, it combines a heat-exchanger, evaporator, refrigerating section, and filter element in one compact unit.—*Hankison Corp., College & Pike, Canonsburg, Penna.*



CIRCLE 196 ON READER-SERVICE CARD

A-C VOLTMETER

New Voltmeter, Model 403A, is a transistorized, compact instrument weighing less than 5 pounds. Frequency range is 1 cps to 1 Mc. Measures a-c voltages from one mv full scale to 300 v full scale. Has 12 voltage ranges and also reads db from −72 to +52 db.—*Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.*

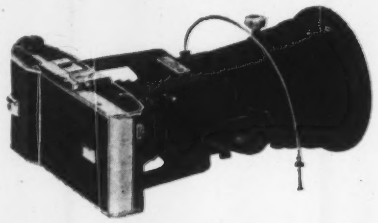


CIRCLE 197 ON READER-SERVICE CARD

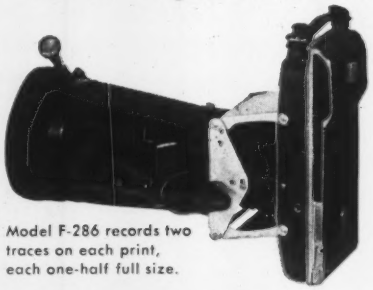
PNEUMATIC SWITCH

New Model J-1 S-1 VP Tandem Magnetrol Head combines a two level stage switching action to provide an electrical switch mechanism (S-1) in a vapor-proof and explosion-proof

Model F-296 makes full-size photo record of single transients or identical repetitive phenomena.



With these Fairchild-Polaroid® Oscilloscope Cameras you can...



Model F-286 records two traces on each print, each one-half full size.

PERMANENTLY RECORD OSCILLOSCOPE TRACES in 20 to 60 seconds!

No special photographic skills are needed with a Fairchild-Polaroid Oscilloscope Camera. Two models are available. One records single, direct-reading, full-size scope images; the other two half-size images on one print. Operation of both is fast and simple, hardly interrupts lab procedures. You can evaluate prints directly in one minute or less, enter photo evidence into reports at once.

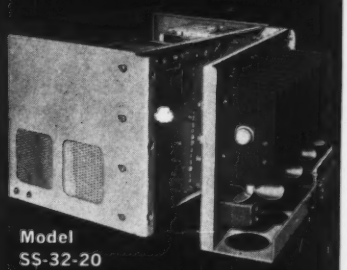
For descriptive literature, write to Industrial Products Division, Dept. 19, Fairchild Camera and Instrument Corp., 5 Aerial Way, Syosset, L. I., N. Y.

INDUSTRIAL PRODUCTS DIVISION
FAIRCHILD
CAMERA AND INSTRUMENT CORPORATION

CIRCLE 97 ON READER-SERVICE CARD

sig-nificantly!

Every NJE Solid State Transistorized Power Supply is built with components that are significantly derated under the most severe combination of line, load and ambient conditions. Components are the highest quality military and commercial types available (every transformer and choke is a MIL-T-27A style unit, every resistor is wire-wound). Proven reliability makes NJE your best Power Supply buy! 14 standard models cover virtually every job. Here's one:

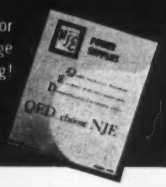


Model SS-32-20

Output, volts: 0-32.
Output, amps: 0-20.
RMS ripple: 1 millivolt.
Regulation, load: ±0.015% or ±1 MV.
Regulation, line: ±0.03% or ±2 MV.
Internal Impedance DC-20KC: 0.02 ohms.

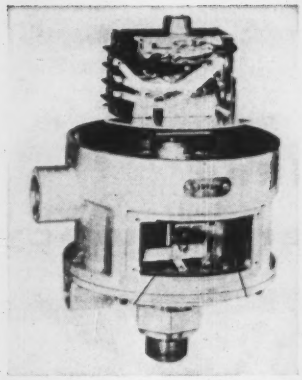
PRICE: $990
FOB Kenilworth, N. J.

Write today for this new 16 page Power Supply catalog!



NJE CORPORATION
20 Boright Ave., Kenilworth, N. J.
Br 2-6000

CIRCLE 98 ON READER-SERVICE CARD



switch housing mounted physically over a pneumatic (J-1) switch mechanism which is splash-proof in its construction. Head can be so set up that either electric or pneumatic action can be secured as the first stage on rising (or falling) level regardless of the physical positioning of each mechanism. Uses either air or gas as operating pressure medium. Available with all styles of Magnetrol actuators—top or side mounting with either threaded or flanged connections.—*Magnetrol, Inc., 2110 South Marshall Blvd., Chicago 23, Ill.*

CIRCLE 198 ON READER-SERVICE CARD

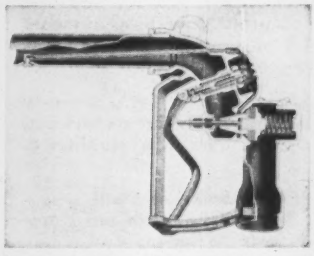
GAS FLOW COMPUTER

New all-electric Gas Flow Computer continuously measures mass flow of gas under standard conditions. Comprises differential-pressure transmitter, an absolute-temperature sensing device, an absolute-pressure transmitter, an analog computing circuit, and an electronic circular or strip-chart recorder.—*Brown Instruments Div., Minneapolis-Honeywell, Wayne & Windrim Aves., Phila. 44, Pa.*

CIRCLE 199 ON READER-SERVICE CARD

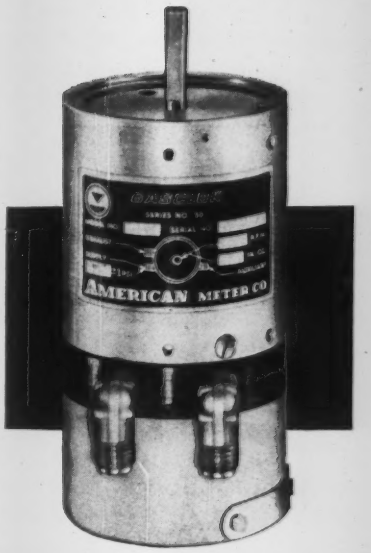
LIQUID LEVEL CONTROL

New patented Sliding Gate and Plate Regulators for liquid level control use plant air to pilot main diaphragm control valve. Feature



tight shut-off and accurate control from 1 to 2500 gpm capacity. Available in ¼" through 6" sizes. Used where critical liquid level control is needed. Details in SRBc 37-59 and Bulletin J-170.—*OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.*

CIRCLE 200 ON READER-SERVICE CARD



AMERICAN®
GASCLOK POWER DRIVE

Completely self-contained gas or air-powered instrument driving and timing unit for long, trouble-free operation in remote locations. The GASCLOK delivers more than 20 times the torque of conventional spring-wound mechanisms. Continuous timing accuracy is unaffected by a ± 20% variation in supply pressure.

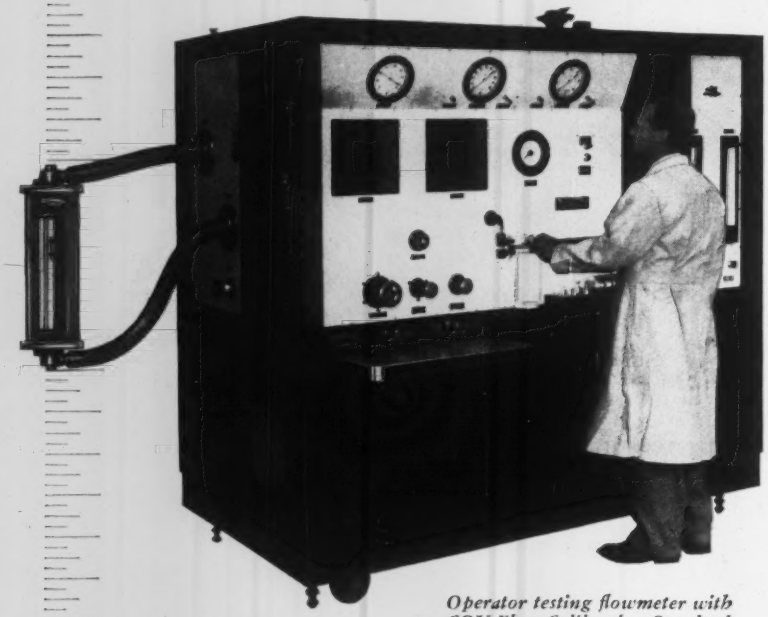
Inherently explosion proof and self-starting, the GASCLOK is ideal as original or replacement equipment for strip chart and conventional circular chart instruments. The timing mechanism is internally sealed to prevent corrosion, and all power unit parts exposed to gas are aluminum or stainless steel. Large area internal ports prevent clogging. Normal air or gas consumption 5 cfh . . . operating pressure 5 psi . . . rotation 2 rpm.

AMERICAN® METER COMPANY
INCORPORATED (ESTABLISHED 1836)

Executive Offices: Philadelphia 16, Pa.
Sales offices in principal cities.

CIRCLE 99 ON READER-SERVICE CARD

How UNION CARBIDE Verifies Flowmeter Accuracy



Operator testing flowmeter with COX Flow Calibration Standard

Periodic checking of liquid flowmeters at the huge Oak Ridge, Tennessee nuclear facility presented a problem to the Union Carbide Nuclear Company, operators of the facility. Checking the instruments required a known standard against which they could be evaluated. Using other flowmeters as masters was of questionable value as they too were subject to the same variables of wear, temperature changes, and viscosity shifts as were the instruments under test.

Union Carbide solved the problem by using a *COX Flow Calibration Standard* (Type 315), the same as those used by flowmeter manufacturers for original instrument calibration. It gives them a *primary standard* of their own — assuring accurate flow measurements that can be correlated with measurements by the National Bureau of Standards.

Costly? Not as much as you'd think for a *primary standard*. And the time normally spent on rechecking, evaluations, and analyzing test data was eliminated.

If you make or use flow measuring devices you will be interested in our new Technical Bulletin on *COX Flow Calibration Standards*. Write to: *Cox Instruments Division, George L. Nankervis Company, 15400 Fullerton Avenue, Detroit 27, Michigan.*

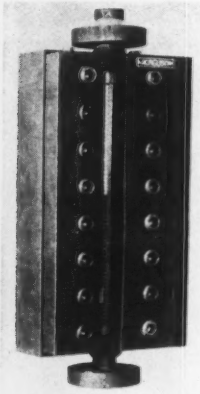
IF IT'S WORTH MEASURING
It's worth measuring accurately 7392

COX Instruments

CIRCLE 100 ON READER-SERVICE CARD

BOILER GAGE

New "Refragage" uses light refraction to give black and white reading for high-pressure boilers. Flood-light illuminator at back of gage passes light rays through an angular pass-

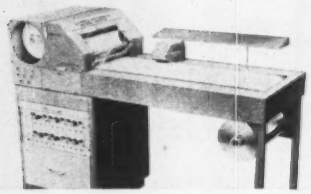


age, and while the light passing through the water is refracted and lost to view, the light passing through the steam area shines brightly through the front line of holes above the water level.—*Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.*

CIRCLE 201 ON READER-SERVICE CARD

RECORDER

New six-channel Recorder fills need for a recorder which allows user to obtain a view of the oscillogram and make notes or corrections with the oscillogram in motion. Unique



feature: oscillogram is transported on a belt along the top of the readout table allowing the operator a full and undisturbed view of nearly three feet of record. Oscillogram width—up 12 in. oscillogram speed—between 1 to 50 mm/sec.—*The Gerber Scientific Instrument Co., 89 Spruce St., Hartford 1, Conn.*

CIRCLE 202 ON READER-SERVICE CARD

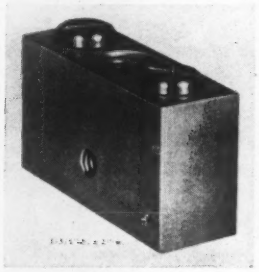
PULSATION ABSORBER

New Type No. 6 is essentially three instruments in one—Snubber, Seal Pots and Syphon. Prevents shock and pulsations that damage and prevent inaccurate reading on gages, recorders, etc. It absorbs and irons out shock and pulsations before reaching the instrument.—*Defender Instrument & Regulator Co., Boody, Ill.*

CIRCLE 203 ON READER-SERVICE CARD

DOUBLE BALL CHECK VALVE

New miniature Double Ball Check Valve features a separate ball for each inlet. If both supply pressures



fail, the two inlets are immediately sealed, preventing bleed-off of downstream pressure.—*George W. Dahl Co., Inc., 86 Tupelo St., Bristol, R. I.*

CIRCLE 204 ON READER-SERVICE CARD

SHAFT-ANGLE DIGITIZER

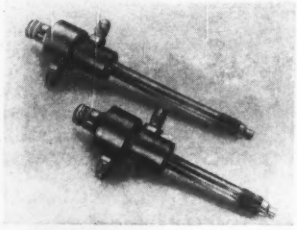
New Dychroverter Model DV-13D Shaft-Angle Digitizer comprises optical-mechanical converter of only 25 in^3 and an amplifier assembly of 37 in^3. A cable up to 3-feet in length carries the 13-digit reading signals

from converter head at the point of measurement to 13 separate amplifier channels. Angle reading is at a rate of 100 complete digital words/sec and to an accuracy of ±2.5 min. —*Dychro Corp., 12 Centre Ave., Newton 58, Mass.*

CIRCLE 205 ON READER-SERVICE CARD

PRESSURE TRANSDUCER

New Dynisco Model PT58 Pressure transducer has response, resolution, and performance necessary to measure small and rapid pressure fluctuations in the plastic melt during the extrusion process. Features: repeatability of 0.1%, operating temperatures of 750°F. Units are available

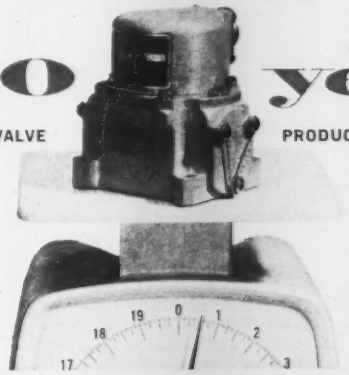


MIDWESTERN MI INSTRUMENTS

LIGHTEST IN THE FIELD!

AND BACKED BY **10 years**

OF SERVOVALVE PRODUCTION EXPERIENCE



MI SERIES 40 SERVOVALVES

ONLY 9.5 OUNCES

DEPENDABLE

Large control orifices, clearances, and high driving forces (½ system pressure with 10% rated current) insure long life and maximum reliability.

MECHANICAL FEED BACK
LOW HYSTERESIS: 2%

Featuring simplified design, the Midwestern Model 40 Series Servovalves have been tooled for production to meet existing and anticipated reliability requirements of military applications. Special effort has been made to lighten weight, improve hysteresis, decrease leakage and reduce susceptability to oil contamination.

Various configurations of the Model 40 are available for three-way or four-way service.

DYNAMICS: Amplitude — 3 db max. at 150 cps.
Phase — 90° at 150 cps. max.
TORQUE MOTOR: Dry gap and coils, hermetically sealed.
LEAKAGE: External, none. Internal, .09 gpm max. (to drain)
RATED FLOW: To 5.0 gpm at 1000 psi valve drop.

WRITE FOR MORE DETAILS! MI PRODUCES:

Oscillographs
Galvanometers
Amplifiers
Bridge Balance Units
Discriminators
Voltage Controlled Oscillators
Magnetic Tape Recorders
Magnetic Recording and Reproducing Heads
Power Supplies
Current Sources
Data Repeaters
Servovalves
Linear Displacement Solenoids
Torque Motors
Servo Amplifiers
Precision Analog Recording Systems
Aircraft Data Acquisition Recorders
Complete FM Ground Station Telemetering Systems

MIDWESTERN INSTRUMENTS

41ST & SHERIDAN RD./P. O. BOX 7186/RI 7-1331/TWX: TU 849/TULSA, OKLA.

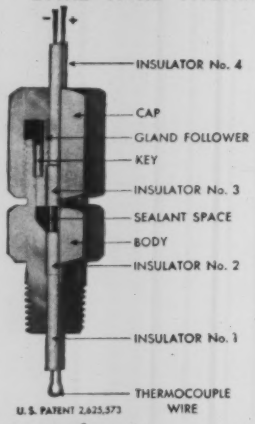
also manufacturers of Magnecord fine tape recording instruments

CIRCLE 101 ON READER-SERVICE CARD

Fast Response

conax®

BARE WIRE THERMOCOUPLE GLANDS



U. S. PATENT 2,625,573

provide the only simple positive method for sealing two or more bare wires at pressures from full vacuum to 20,000 psi.

Low mass, unshielded, bare wire thermocouples give almost instantaneous response to temperature changes assuring greater accuracy of measurement and control.

- **Temperature range— —300°F to +1850°F**
- **All stainless steel construction**
- **Complete range of sizes**
- **Available from stock**

WRITE FOR CONAX DATA BOOK SHOWING COMPLETE LINE OF THERMOCOUPLE ASSEMBLIES AND PRESSURE SEALING GLANDS.

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CIRCLE 102 ON READER-SERVICE CARD

automatic engine controls

full automatic controls
d.c. solenoids
relays and contactors
speed sensitive switches (1, 2 & 3 element)
special control panels
liquid temperature switches
oil pressure switches
safety alarm panels

SYNCHRO-START PRODUCTS, INC.
Since 1932
8151 NORTH RIDGEWAY AVENUE, SKOKIE, ILLINOIS

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For Highest Precision and Dependability

CARL ZEISS JENA

LARGE TOOLMAKER MICROSCOPE

6" x 2" RANGE
11" Diameter Built-in Rotary Table
Indexing Full 360°

For the Complete Story of this Outstanding Precision Tool — Contact any of our 3 "Coast to Coast" Locations or your nearest Local Distributor.

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PRECISION MEASURING TOOLS AND INSTRUMENTS

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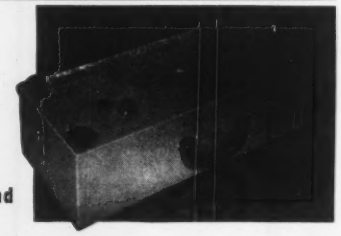
CIRCLE 104 ON READER-SERVICE CARD

PORTABLE... ACCURATE... EASY TO OPERATE...

Sprengnether's Blast and Vibration Seismograph



PROVIDES EFFECTIVE, SIMPLE METHOD OF ANALYSING AND DETERMINING TRUE VALUE OF VIBRATIONS.....

Typical Applications:

- Explosive Testing
- Rocket Engine Testing
- Measuring Vibration Effects to Plant and Equipment from Operating Heavy Machinery.
- Determine Vibration Response of Members During Construction and After Completion of Building.

Portability: (38 lbs.—25 x 10 x 8 in.) Unit is self contained and free from external power source.

Extremely Accurate: To guard against error, each instrument is tested and calibration data furnished. Frequency response, 3 to 200 cycles per second. Timing lines are across record at intervals of 0.02 seconds with accuracy of 0.1%.

Easy To Operate: All controls are easily accessible. Instrument can be set up, leveled and made ready to operate within minutes.

Write today for complete information.

Internationally Known Mfrs. of Seismological, Geophysical Instruments.

W. F. SPRENGNETHER INSTRUMENT CO., INC.
4567 SWAN AVENUE • ST. LOUIS 10, MO.

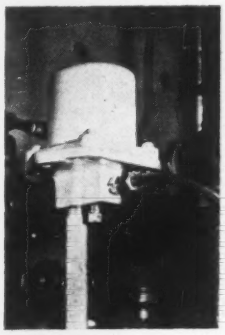
CIRCLE 105 ON READER-SERVICE CARD

for the complete pressure range of 0-1000 to 0-10,000 psi.—*Dynamic Instrument Co., Inc., 42 Carleton St., Cambridge 42, Mass.*

CIRCLE 206 ON READER-SERVICE CARD

RESISTANCE PRESSURE DETECTOR

New Resistance Pressure Detector, Model 328, can measure gas, fluid or vapor pressures in combination with "Omniguard" monitor; converts

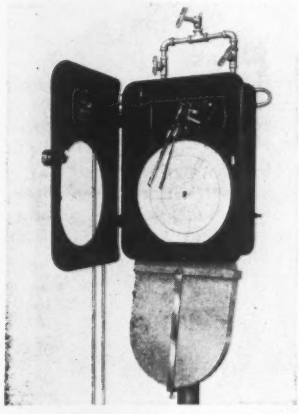


pressure directly to electrical resistance. Features: rugged, accurate, reliable yet inexpensive. Ranges from in Hg to 3000 psig.—*Instrument Div., Thomas A. Edison Industries, McGraw-Edison Co., West Orange, N. J.*

CIRCLE 207 ON READER-SERVICE CARD

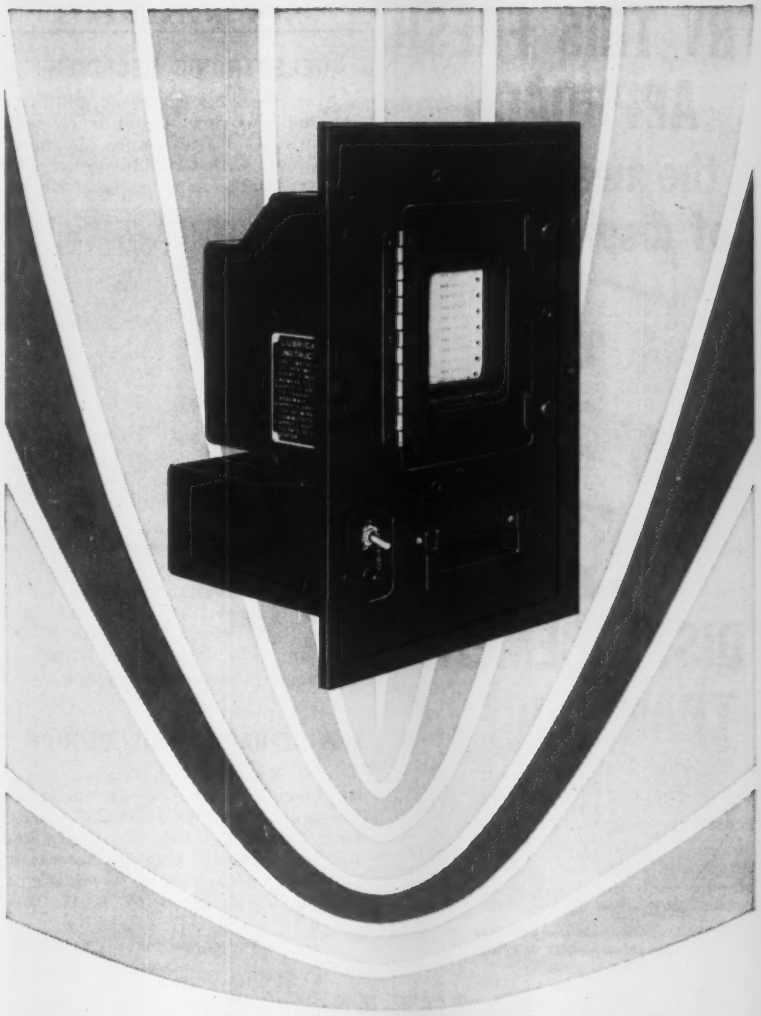
AUTOMATIC CHART CHANGER

New Automatic Meterman affords utilization of up to forty circular charts in a single recorder; it disengages the charts, one by one, at virtually any desired time/date frequency and drops them by gravity



into a self-contained storage box. Uses only a minute portion of available clock power. Can be used on all circular-chart recorders of any diameter on thickness.—8-page pocket folder gives details.—*Maeder-Squier Co., Box 5145, Dallas 22, Texas.*

CIRCLE 208 ON READER-SERVICE CARD



NEW CLARY MILITARIZED PRINTER

WITHSTANDS 50G SHOCK!

The new Model 2000 series printers designed by Clary will print digital data even under the extreme environmental conditions encountered in military use • These rugged, reliable printers are constructed on a sturdy panel for vertical rack mounting, and contain all necessary electronic equipment for data decoding, digit selection, and control functions of the printer • They are designed to print the output from computers, digital voltmeters, shaft position transducers, electronic counters and digital clocks. In addition, they are ideal in industrial applications where continuous, unfailing operation is required • For complete information on how Clary Model 2000 series can help you, write today for Engineering Bulletin S-120 •

Clary

Electronics Division

San Gabriel, California

CIRCLE 106 ON READER-SERVICE CARD

TRY THIS FRESH APPROACH
to the measurement of displacement

DISPLACEMENT TRANSDUCERS

No longer are weak outputs a problem in the application of displacement transducers to the measurement or indication of mechanical movements electrically.

You have a reliable source for displacement transducers—International Resistance Company—offering you a vastly superior precision product *at a lower cost.*

Better Linearity—as low as 0.1%
Better Sensitivity—2.0 MV/Volt Input/Mil at 60 cycles
Linear Range: .005" to 4.0"
Frequency: 50 to 20,000 CPS
Null Voltage: 0.25% of total output, or less
No moving parts to wear
Longer, Infinite Life
Resolution: Infinite
Precision assured by close control at every step in manufacture

Special designs available for:
- **High temperature (1200°F)**
- **Nuclear radiation resistance**
- **120V. inputs; up to 50V. outputs**
- **Zero temperature coefficient**
- **Matched units for complete interchangeability**

For complete information including many more advantages of IRC Displacement Transducers write for Bulletin R-3b.

Compu-tran

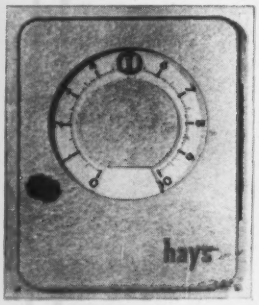
International Resistance Company
COMPUTER COMPONENTS DIVISION
Dept. 454, 401 N. Broad St., Philadelphia 8, Pa.
In Canada: International Resistance Co., Ltd. Toronto, Licensee.

CIRCLE 107 ON READER-SERVICE CARD

NEW INSTRUMENTS

ELECTRONIC RECEIVER

New Model 721 Electronic Indicator can indicate flow, liquid level, temperature, % O_2, resistance, d-c millivolts, etc. Either of two electronic receiver units can be incorporated

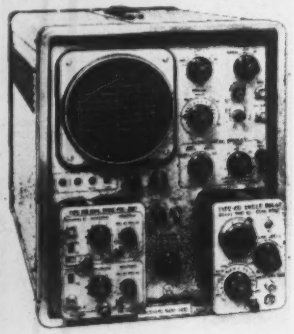


for operation with suitable transmitters—a differential transformer receiver, or a slidewire receiver. Features 4.4-sec pointer travel full scale, with 300-degree indication and total scale length of 12¾".—*Hays Corp., Michigan City, Ind.*

CIRCLE 167 ON READER-SERVICE CARD

WIDE-BAND OSCILLOSCOPE

New Model K-120 Single-Channel Oscilloscope features an accurate sweep delay with 18 calibrated ranges from 2 μsec to 1 sec per centimeter as an optional plug-in accessory. Other features include a wide-band vertical amplifier with 0.017 μsec



rise time, sweep lock-out, beam position indicators, single knob calibrator and sweep controls, and others that simplify operation and waveform analysis. Several plug-in pre-amplifiers are also available.—*Electronic Tube Corp.* 1200 *E. Mermaid Lane, Phila.* 18, *Pa.*

CIRCLE 168 ON READER-SERVICE CARD

THERMISTOR THERMOMETER

New thermistor-actuated Temperature Indicator, Model 116, is available in nine ranges covering −30 to 350°F. Sensing probes are inter-

TYPICAL EXAMPLE of a Fairchild Motion Analysis Package includes Motion Analysis Camera HS401 with high-speed HS504-B1 kit (speeds from 2100 to 8000 pps), light meter, power supply, timing light generator, camera and event synchronizer, special tripod, slave timer for rapid start-stop, and Mini-Rapid Processor.

ALL YOU NEED FOR PHOTOGRAPHIC MOTION ANALYSIS

— in a single Fairchild package

With a Fairchild integrated camera system, engineered to your requirements, you benefit these 4 ways:

1. **Immediate answers** to your problem. You can shoot and develop 100 feet of film in as little as 20 minutes.
2. **Ease of operation.** All units are compatible with each other. No other equipment is needed. Operation is simple and quickly learned.
3. **Portability.** Light-weight, compact construction permits you to carry the equipment anywhere — even store it in your car trunk — and set it up quickly.
4. **Service.** An experienced Fairchild Sales Engineer will gladly help you determine the package most suitable for your needs, and help you with basic applications.

Write for booklet "Conserve Valuable Engineering Hours" to Industrial Products Division, Dept. 22, Fairchild Camera and Instrument Corp., 580 Midland Ave., Yonkers, N. Y.

INDUSTRIAL PRODUCTS DIVISION
FAIRCHILD
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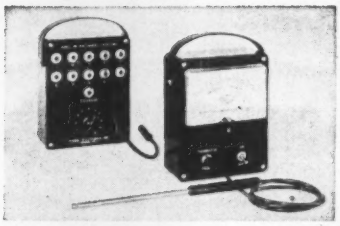
Represented in the 11 Western States by Gordon Enterprises, 5362 N. Cahuenga Blvd., No. Hollywood, Calif.

CIRCLE 108 ON READER-SERVICE CARD

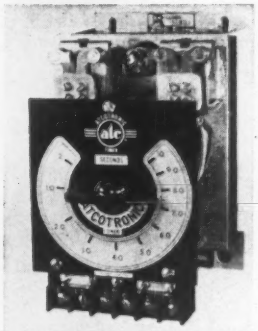


changeable and accurate to 0.5°F under 100°F, and 0.5% of reading over 100°F. Can be used with Model 119 Channel Selector for readout of ten temperature points.—*Fenwal Electronics, Inc., Mellen St., Framingham, Mass.*

CIRCLE 169 ON READER-SERVICE CARD

ELECTRONIC TIMER

New printed-circuit electronic Timer for short interval time control, Model 5231-B, features two heavy-contact, four-pole, double-throw re-

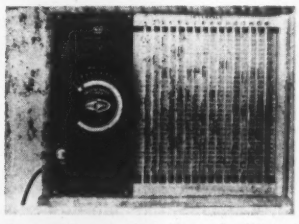


lays rated at 15 amp. Variety of timing ranges available, including 0.02 to 1 sec. 0.5 to 30 sec. etc. Maximum standard ranges available are 60 and 120 sec.—*Automatic Timing & Controls, Inc., King of Prussia, Penna.*

CIRCLE 170 ON READER-SERVICE CARD

TIMER

New Interchron Timer Model 52 controls from 1 to 16 intervals of up to 30 min in 10-sec increments; entire program can be repeated through use of a reset control switch. Accuracy is within 1% of the 30-min



maximum for each interval. At end of each interval a chime sounds for timing manual operations and an electrical contact closes momentarily to operate relays, switches, etc.—*Bald Eagle Corp., 356 Cedar St., St. Paul, 1, Minn.*

CIRCLE 171 ON READER-SERVICE CARD

The NEW Series BH100

MILLI-V-METER®

THE INSTRUMENT with the TAPE-SLIDEWIRE

1/10 THE SIZE...

10 TIMES THE ACCURACY

OF STANDARD INSTRUMENTS!

- *Resolution: 1 part in 10,000*
- **LABORATORY PRECISION for the operating plant.**
- **COMPATIBLE with any transducer—AC or DC.**
- **For strain gage, linear differential transformer, thermocouple, thermistor, resistance thermometer, pulse or variable frequency circuits or systems.**
- **Parabolic or logarithmic functions are linearized for direct digital reading.**
- **Every scale unit is a calibrated value.**

Produced by the makers of the JETCAL® *jet engine Analyzer... in worldwide military and airline use!*

* TRADE MARK

Full information is available for the asking!

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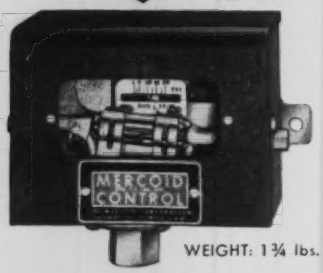
CIRCLE 109 ON READER-SERVICE CARD

NEW

Small, Lightweight

MERCOID PRESSURE CONTROL

AP-153



WEIGHT: 1¾ lbs.

FOR MEDIUMS NOT INJURIOUS TO STEEL OR SILVER SOLDER

CIRCUIT

SP-DT HERMETICALLY SEALED MERCURY SWITCH (4A. 115V., 2A. 230V.)

Provides any of following operations:

1. *Single Pole—Cut-in high (close on rise)*
2. *Single Pole—Cut-in low (open on rise)*
3. *Single Pole—Double Throw*

OPERATING RANGE

ADJUSTABLE OPERATING RANGE	SWITCH DIFFERENTIAL PSIG. With Pointer Set At LOW	HIGH
1 to 20 psig.	0.3	0.5

CONSTRUCTION

ADJUSTMENT: External
PRESSURE ELEMENT: Fairprene diaphragm
PRESSURE CONNECTION: ¼" I.P.S.
MOUNTING: Has two mounting ears (one on each side of control) or control may be pipe mounted by means of the ¼" I.P.S. bottom connection.
INTERNAL WIRING CONNECTIONS: 3 post terminal block.
CASE: NEMA 1—Heavy gauge steel, cadmium plated. Steel cover (with glass front) finished in charcoal-gray.

WRITE FOR BULLETIN 02

THE MERCOID CORPORATION
4201 Belmont Ave., Chicago 41, Ill.

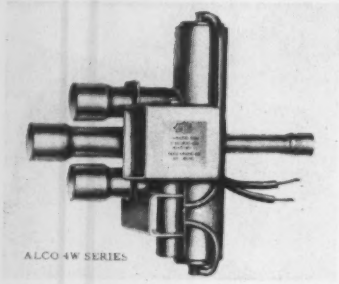
CIRCLE 110 ON READER-SERVICE CARD

STRAIN GAGE CEMENTS

New EPY-150 and EPY-400 Epoxy Cements, formulated for use with bonded-filament strain gages, have maximum service temperature of 150°F and 400°F respectively. Furnished in small plastic packs, each divided into two compartments containing the liquid adhesive and the activator, respectively. Cement is mixed for use simply by removing the split metal pin which divides the pack and kneading with the fingers. —*Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass.*

CIRCLE 209 ON READER-SERVICE CARD

4-WAY REVERSING VALVE

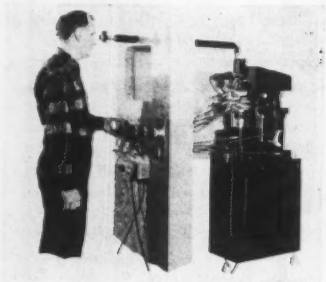


CIRCLE 210 ON READER-SERVICE CARD

New 4-way Valve in the 4W Series having a slide of cast iron and an outer shell of steel, needs no plastics for sealing or tight seating on account of fine machining and precision honing. Contains a carefully-balanced dashpot action to prevent mechanical hammering during shifting. Can be mounted in any position except with the pilot valve upside-down. Can be installed to shift to cooling or to heating on power failure for the "fail safe" position.—*Alco Valve Co., 865 Kingsland Ave., St. Louis 5, Mo.*

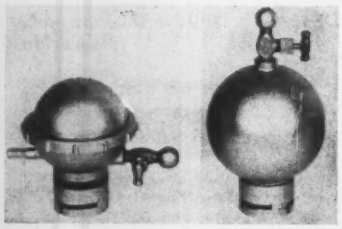
MICROHARDNESS TESTER

New Tukon Tester is designed for shallow-indentation hardness testing of "hot" metals or metal components that have been exposed to radioactive or nuclear-energy contamination. Features: remote-control automatic timing cycle of load application; vibration absorbing supports; vertical capacity of 5" without the Microton mechanical stage, 3½" with stage. Can accommodate test pieces up to 8" in height.—*Wilson Mechanical Instrument Div., American Chain & Cable Co., 929 Connecticut Ave., Bridgeport 2, Conn.*



CIRCLE 211 ON READER-SERVICE CARD

IONIZATION CHAMBER

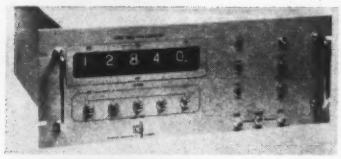


New spherical gas phase Ionization Chamber and a new Slide Chamber for solid and liquid samples eliminate "dead" space due to spherical design, so saturation is obtained at 90 volts or less for all ordinary currents. Slide chamber, 600 ml capacity, holds 2 sample planchets of 2¼" or smaller diameter.—*Applied Physics Corp., 2724 South Peck Rd., Monrovia, Calif.*

CIRCLE 212 ON READER-SERVICE CARD

TIME CODE GENERATOR

New Model 1021 Generator consists of a crystal-controlled oscillator and seven decades of frequency division. Produces 8 separate timing signals—100,000 to 0.01 cps; each signal



coded by a different width. Mixed output range is 100 to 0.01 cps on a single channel.—*Computer-Measurements Co.*, 12970 *Bradley Ave., Sylmar, Calif.*

CIRCLE 213 ON READER-SERVICE CARD

RECHARGEABLE SILVER-ZINC BATTERIES

New line of silver-zinc secondary (rechargeable) Batteries has high energy-to-weight ratios. Cells can be combined to develop power required. Cells range in size and output from Type SC-04 miniature cell of 0.5 amp-hour capicity (weight 0.05 pound) to Type SC-450, a single cell with a weight of 9.7 pounds and an output of 450 amp-hours. All cells are rated with a terminal voltage of 1.4 v under load.—*Cook Batteries*, 3850 *Olive St., Denver* 7, *Colo.*

CIRCLE 214 ON READER-SERVICE CARD

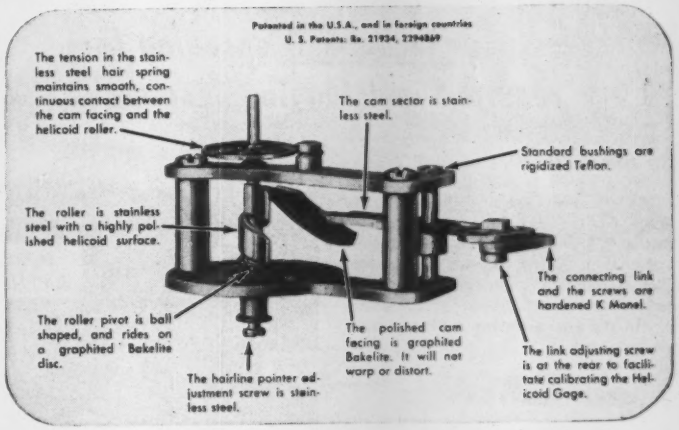
TRANSMITTING POTENTIOMETER

New Microsen Series E170 Transmitting Potentiometer, converting low-level d-c signals to proportional 1.0 to 5.0 ma d-c signals, is a seminullbalance, resistance-bridge design

with modular construction. Available with thermocouples or resistance bulbs for straight or differential temperature measurements. Also for millivoltage inputs as low as 0-10 mv, for current inputs as low as 0-10 μa and for service with strain gages and re-transmitting slidewires.—*Manning, Maxwell & Moore, Inc.*, 250 *E. Main St., Stratford, Conn.*

CIRCLE 215 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

HELICOID GAGES

ACCO

Helicoid Gage Division • American Chain & Cable Company, Inc.

929-B Connecticut Ave., Bridgeport 2, Conn.

CIRCLE 111 ON READER-SERVICE CARD

DIGITAL TRANSDUCER

provides mechanical encoding for read-out and logging systems

The new Series 400 Digital Transducer utilizes a standard sensing element (flow, pressure, or temperature) to actuate the mechanical American Force Amplifier which precisely positions a shaft encoder. The need for electronic accessories is eliminated. Increased reliability and simpler maintenance are assured.

SERIES 400

SPECIFICATIONS

Accuracy: 1% of span.
Repeatibility: 0.5% of span.

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AMERICAN METER COMPANY

MECHANICAL COMPONENTS DEPARTMENT
BOX 309 • GARLAND, TEXAS

CIRCLE 112 ON READER-SERVICE CARD

SPECIAL KEYBOARDS

Any number of keys, bars, switches or lights in any arrangement you require—wired to your specifications.

Concord Keyboards can be found working with many different types of equipment throughout the United States and Canada. Only proven components with exceptionally long life characteristics are used. A typical example: a keyboard that has twelve keys and one bar, wired to a cable and connector with a steel case painted grey—$220. Delivery three to five weeks. Send us a sketch of your desired key layout and wiring specifications for an immediate estimate.

Also call upon us for your special requirements for paper tape or magnetic tape input equipment.

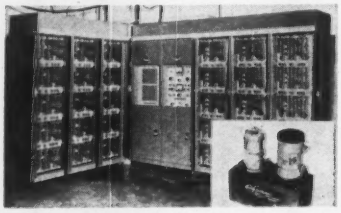
CONCORD CONTROL INC
1282 Soldiers Field Road, Boston, Mass.

CIRCLE 113 ON READER-SERVICE CARD

NEW INSTRUMENTS

ANALOG-DIGITAL LINK

New miniature Servo Package provides linkage between an analog and digital computer in new Addaverter

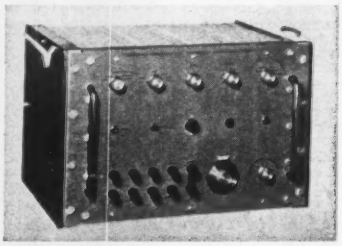


data conversion device. Comprises two gear clusters with a ratio of approximately 40:1 between the size 8 servo motor and the 1K potentiometer.—*Bowmar Instrument Corp., 8000 Bluffton Rd., Fort Wayne, Ind.*

CIRCLE 216 ON READER-SERVICE CARD

FUNCTION GENERATOR

New Function Generator, Model LF 51, designed by Servomex of England, generates over 37 different waveforms for testing servomechanisms, for vibration studies, medical research or geological problems; or

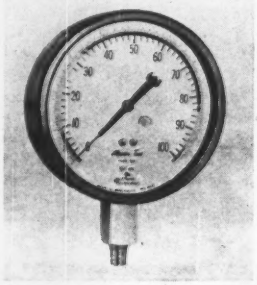


for programming automatic systems and analog computation. Instrument comprises 16 modules plus a fully-stabilized power supply. It will withstand 40 g's in any direction.—*Marconi Instruments, 111 Cedar Lane, Englewood, N. J.*

CIRCLE 217 ON READER-SERVICE CARD

PRESSURE GAGES

New Series 200 Master-Test line of Pressure Gages is individually deadweight tested and guaranteed accurate within ±¼% of the maximum dial reading over the entire range. Features include new "read-easy"



dial, "twin-tip" pointer, mirror dial (see illustration), or "non-parallax" dial. Available sizes are 4¼", 6" and 8".—*Marsh Instrument Co.*, 3501 *Howard St., Skokie, Ill.*

CIRCLE 218 ON READER-SERVICE CARD

POWER ISOLATOR

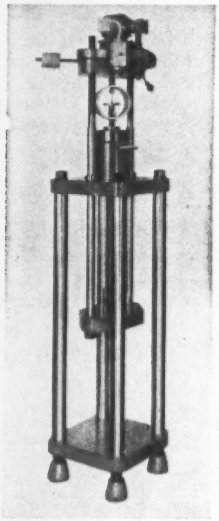
New portable Model 30 Power Isolator provides a 300-va (at 60 cps, 115 vac) output isolated from line voltage and line ground. Thus line-operated devices can be supplied with

ideal isolation without a common ground. Isolation insures flow of only mμamps of 60-cps line current from its output to line ground. The loading of the output to ground is less than 2μμf capacitance and greater than 50,000 megohms.—*Moeller Instrument Co., Electronics Div., 132nd St. & 89th Ave., Richmond Hill 18, N. Y.*

CIRCLE 219 ON READER-SERVICE CARD

LOAD CELL CALIBRATOR

New Load Cell Calibrating Machine features new yoke to add mo-



torized or mechanical adjustment which speeds up calibration.—*Morehouse Machine Co.*, 1742 *Sixth Ave., York, Penna.*

CIRCLE 220 ON READER-SERVICE CARD

in process
safety-relief valves

From the Near East to our own Far West . . . the name Farris on safety-relief valves has been a standard synonym for safety since 1943. The patented design features on all Farris full-nozzle valves combine to offer the ideal concept of a trouble-free, 100% safe safety-relief valve for every application.

SERIES 2600

The most popular top-guided, self-aligning, safety-relief valve for process piping service. Maximum pressure, 150 to 2500 psig. RF/RJ. Plain or Lever types. Standard or BalanSeal bellows construction.

SERIES 2740

A cast-steel relief valve of simplified design for use where extreme blow down accuracy is not essential, but where durability, compactness are. Pressures to 3500 psig at 450°F; 2000 psig at 800°F. Sizes ½" to 2".

SERIES 2745

An extremely rugged, compact, high pressure bar stock nozzle valve. Internal parts stainless steel. Adjustable blow down; flat seat; self-aligning stem and disc. Pressure to 10,000 psig. Sizes ½", ¾", 1".

SERIES 2950

A cast iron safety-relief valve including most of the exclusive Farris features found in the Series 2600. Max. pressure, 250 psig at 450°F, 400 psig at 150°F. Plain cap, open lever or packed lever types.

Complete information is provided in Catalog FE-118, covering both selection and sizing of Farris process Safety-Relief Valves. Send for your copy today.

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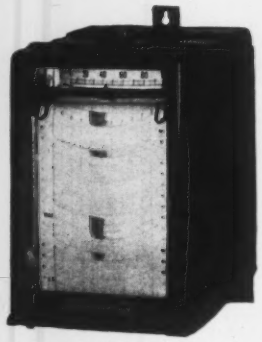
CIRCLE 114 ON READER-SERVICE CARD

BEST BY *DESIGN*

—Not by *Chance*

Constant attention to the wants and needs of users, has been worked into the finished recorder by trained designers, who devote their entire effort to producing the best in direct-writing recorders. *E-A Recorders are designed to be the best.* Performance has proved their superiority.



Ask for Catalog 657

PRODUCT REPRESENTATIVES IN MOST PRINCIPAL CITIES

The ESTERLINE-ANGUS Company, Inc.

Pioneers in the Manufacture of Graphic Instructments

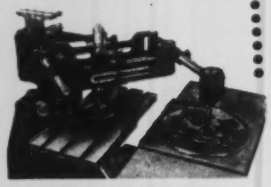
Dept. G, P. O. Box 596, INDIANAPOLIS 6, INDIANA

CIRCLE 115 ON READER-SERVICE CARD

how to get

faithful 3-dimensional reproduction

in steel, other metals and plastics



Use the LOW COST precision-built Preis Panto 3D-5 Engraving Machine. Does both 2 and 3 dimensional engraving effortlessly.

- Reversible spindle for enlarging or reducing from a model, die or sample
- Precision ball bearings throughout
- Reduction ratio range—1.6:1 to 7:1
- Four spindle speeds—7,000 to 18,000 RPM
- Micrometer adjustment collar
- Provided complete with floor stand and work tables

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Write for complete details and prices. For immediate attention write directly to manufacturer below. Ask for nearest representative.

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Packaged Systems

Catalog upon request

John Unertl Optical Co.

3551-3555 East Street

Pittsburgh 14, Penna.

CIRCLE 117 ON READER-SERVICE CARD

CONTACT METER CONTROLLER

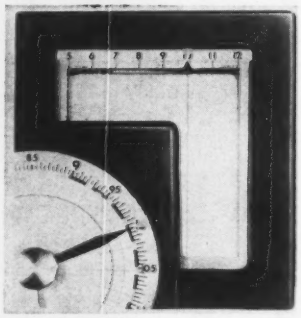
New Model MR Transistorized Contact Meter Controller continuously indicates any electrical variable and

provides high or low limit control. Complete packaged plug-in units of contact meter, built-in transistor amplifier, power supply, and load relay. Accuracy of indicating is 2%, sensitivity 1 μw, repeatability is less than 1% of full scale.—*Larson Instrument Co., 24 Orchard St., Tarrytown, N.Y.*

CIRCLE 221 ON READER-SERVICE CARD

TEMPERATURE CONTROLLER

New Speedomax H Recording Controllers for steam temperature control are made in two models: Model S (strip chart) is for detailed records

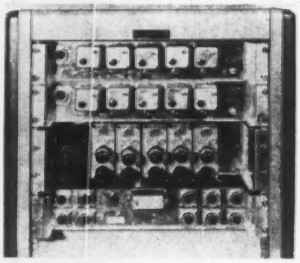


with its 6½" linear scale; Model R (round chart) is recommended for bold indication. Range is 500° to 1200°F; accuracy is better than ±0.3%; sensitivity better than ±0.1%.—*Leeds & Northrup Co., 4934 Stenton Ave., Phila., 44, Pa.*

CIRCLE 222 ON READER-SERVICE CARD

ITV SWITCHING SYSTEM

New AVS-X System, capable of switching signals from any number of TV cameras to any number of viewing monitors, uses plug-in modules throughout. A typical installation consists of one or more ADM-1

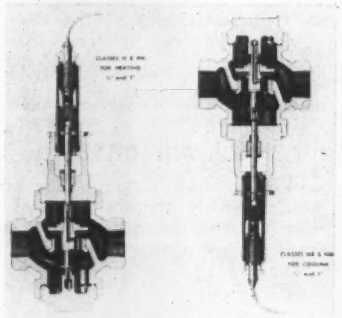


input modules, an ADA-1 Amplifier Rack with amplifiers, an ADH-1 Control Distribution Panel, and one or more ADS-6 Remote Video Switchers. An important feature is that the signal distribution plan is determined by a coded shorting plug.—*Kin Tel Div., Cohu Electronics, 5725 Kearny Villa Rd., San Diego 12, Calif.*

CIRCLE 223 ON READER-SERVICE CARD

TEMPERATURE REGULATOR

New self-actuated temperature regulators—Class M (direct acting) for heating service, and Class MR (reverse acting) for cooling service—

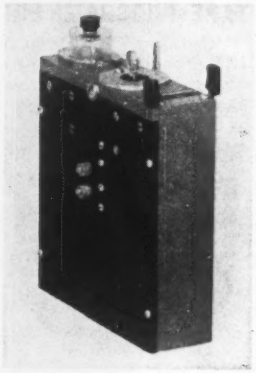


made in ¾" and 1" body sizes in both cast iron and bronze with screwed ends, feature a unique balancing bellows which permits smooth functioning at inlet pressures and pressure drops up to 100 psi; and a self-aligning, single-seated, tight-closing main valve which is guided throughout its entire stroke.—*Leslie Co., 122 Delafield Ave., Lyndhurst, N. J.*

CIRCLE 224 ON READER-SERVICE CARD

TRANSISTORIZED GALVANOMETER

New Model G3 Transistorized Galvanometer provides high current gains up to 1000 and voltage gains up to 15. Input impedance ranges

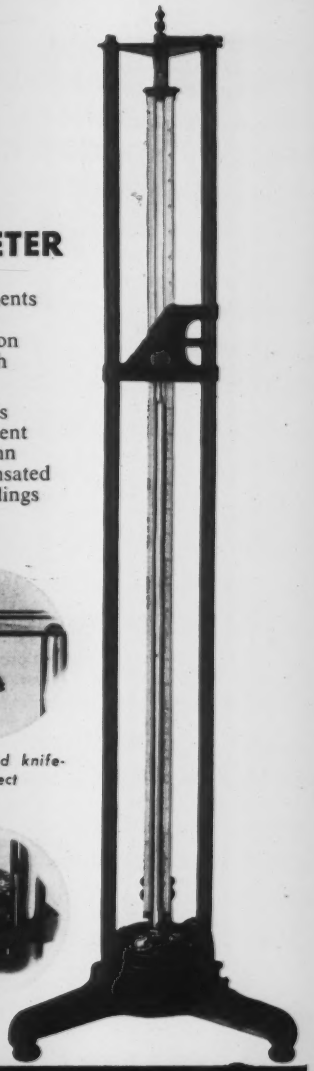


from 200 to 2300 ohms. Linearity is ±1.5% of full scale. Temperature stability is assured with silicon transistors.—*Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, Ohio.*

CIRCLE 225 ON READER-SERVICE CARD

measure absolute and differential pressure accurately, easily with

W & T PRECISION MERCURIAL MANOMETER

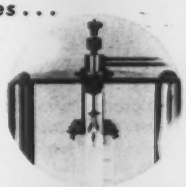


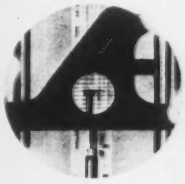
For all types of precise pressure measurements in production, research, or analysis, the Wallace & Tiernan Type FA-135 Precision Mercurial Manometer gives readings with an accuracy of 1:3000.

And the W&T Mercurial Manometer is convenient to use. It is the one instrument which permits reevacuation of its column at any time. Scale is temperature compensated and no zero adjustment is required. Readings are taken at a glance.

unique, advanced features . . .

Mercury-sealed valve provides easy means for evacuating and sealing the tube.





Magnifying eyepiece and knife-edge indicator give direct readings.

Simple dial setting compensates for ambient temperature changes. No mathematical corrections required.

For full information on all models of W&T Precision Mercurial Manometer, write Dept. A-125.48

WALLACE & TIERNAN INCORPORATED

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FOR MORE INFORMATION ON FEEDERS CIRCLE 119 ON READER-SERVICE CARD

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THERMAL CONDUCTIVITY
GAS ANALYSIS SINCE 1935

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	✓	Matched Pairs Hot Wire Filaments (in stock)	✓	
	✓	Detectors VPC • Hot Wire • Thermistor	✓	
	✓	T/C Cells—On Stream	✓	
✓	✓	Temperature Regulated Cells • Hot Wire —to 400° C • Thermistor—to 100° C	✓	✓
✓		GAS GRAND-MASTER—Portable T/C Analyzer • Amplified output for readout by RUSTRAK or ESTERLINE ANGUS recorders		✓
✓		Semiconductor Special Power Supply for T/C Cells and VPC Detection • Microdial zero control • Low noise for 0-1 mv recorder readout		✓

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CIRCLE 120 ON READER-SERVICE CARD

JOHN WORLEY JEWEL COMPANY · 1900 ·

JEWEL BEARINGS and TUNGSTEN CARBIDE BEARINGS and ORIFICES
in
Sizes under 1/4" O. D.

We specialize in instrument bearing design problems and production of pilot lots in our own plant in the U.S.A. We also offer top quality Swiss imports at low production prices.

JOHN WORLEY JEWEL CO.
No. Falmouth, Massachusetts

CIRCLE 121 ON READER-SERVICE CARD

HARDNESS TESTING

SCLEROSCOPE
FOR TESTING THE HARDNESS OF METALS. PIONEER AMERICAN HARDNESS STANDARD. OVER 40,000 IN USE. (ASTM A427)

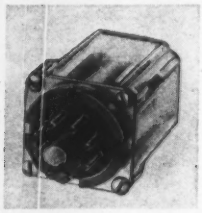
DUROMETER
FOR TESTING THE HARDNESS OF RUBBER & RUBBER-LIKE MATERIALS (ASTM D676) (ASTM D1484)

SHORE INSTRUMENT & MFG. CO., INC.
90-35 VAN WYCK EXP.
JAMAICA 35, N. Y.

CIRCLE 122 ON READER-SERVICE CARD

D-C RELAY

New Series 5D1C d-c relay is a polystyrene-enclosed plug-in unit with 8-pin octal plug-in mounting.



Easily removable case permits field adjustment without special equipment. Coil resistances of 500-13,000 ohms are maintained in stock.—*Kurman Electric Co.*, 191 *Newel St.*, *Brooklyn* 22, *N. Y.*

CIRCLE 226 ON READER-SERVICE CARD

SMALL AIR DRYER

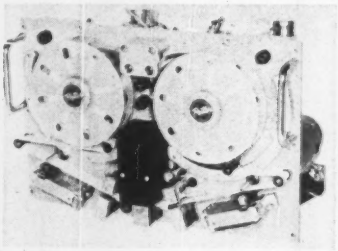
New Budget Air Dryer is for applications which require extremely dry air in small quantities, up to 20

cu-ft/min. Cycle of adsorption and reactivation is automatic until shut down. Range is from 5 psig to 150 psig.—*Pittsburgh Lectrodryer Div.*, *McGraw-Edison Co.*, *P. O. Box* 1766, *Pittsburgh* 30, *Penna.*

CIRCLE 227 ON READER-SERVICE CARD

TAPE PROGRAMMER

New Perforated Tape Programmer, Model 3277, for use in military checkout systems, features bi-directional drive, character reading rates up to

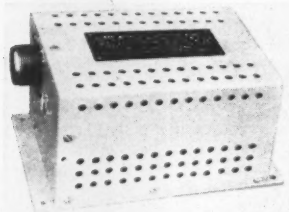


200/sec, tape widths up to 1", and self-contained electronics for control and data playback. Conforms to MIL-E-16400.—*Potter Instrument Co., Inc.*, *Sunnyside Blvd.*, *Plainview*, *N. Y.*

CIRCLE 228 ON READER-SERVICE CARD

FREQUENCY CONVERTER

New series of Power Converters from variable frequency to constant frequency features ±0.01% frequency regulation, and 78% efficiency. In-

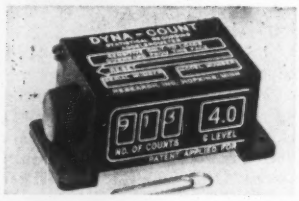


put-voltage range is from 95 to 135 vac, and input frequency range is from 360 cps to 980 cps. Models are available up to 3000 va.—*Power Supplies, Inc., Highland, Ill.*

CIRCLE 229 ON READER-SERVICE CARD

RECORDING ACCELEROMETER

New low-cost Dyna-Count, recording mechanical shocks perpendicular to its mounting surface, is completely self-contained and self-energized (like a self-winding wrist watch). Its digi-

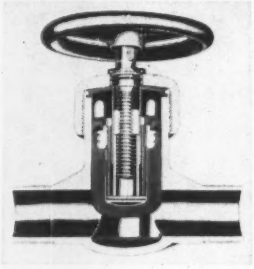


cal uses are in evaluation of the cushioning effect of protective packaging, in tests of vehicle springing or road bumpiness, and in structural strength analysis.—*Research, Inc., 115 North Buchanan, Hopkins, Minn.*

CIRCLE 230 ON READER-SERVICE CARD

PLASTIC VALVE

New all-plastic Hand Valve features tight sealing by a soft-rubber cup which is forced to the concave bottom of the passage, and straight-through design, with screwed,



flanged, or socket ends. The working pressure is 145 psig although all valves are tested at 230 psig. Available sizes are from 1" to 4".—*W. S. Rockwell Co., 200 Eliot St., Fairfield, Conn.*

CIRCLE 231 ON READER-SERVICE CARD

Versatility **makes the difference in the** *Thermo Electronic*® **Indicating Recorder**

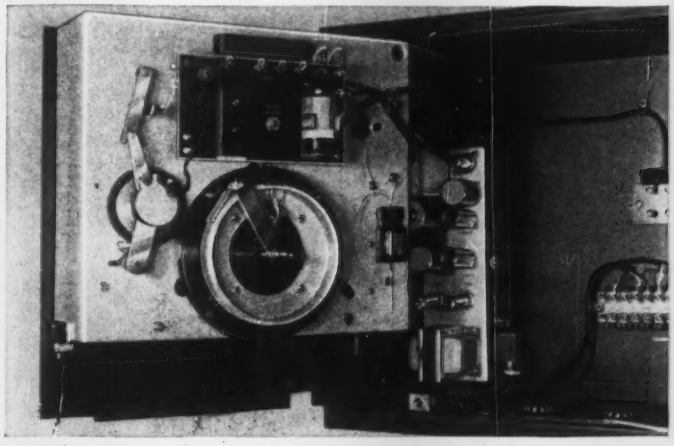
No matter what your application, you can rely on Thermo Electronic Recorders for unsurpassed accuracy, sensitivity and stability. Both potentiometer and bridge types are available. These instruments will automatically indicate and record any process variable (temperature, humidity, pH, conductivity, power, strain, etc.) that can be converted to a voltage or resistance change. Instrument accuracy is ± 0.25% of full scale, sensitivity is ± 0.125% and full scale pointer and pen travel is 5 seconds. The 34" scale and indicating pointer are clearly visible from a great distance.

In use, you get a continuous fine-line circular chart record of your process. Recording pen rarely needs refilling. Easily interchanged ranges permit recording of an almost unlimited variety of process variables.

The heart of the Indicating Recorder is the exclusive Thermo Electronic high-gain servo-amplifier, which couples exceptional stability (± 1 microvolt) with extreme sensitivity. It will maintain operating characteristics even under the most adverse conditions. This guarantees consistently accurate performance in recording your process functions. Full sensitivity of the amplifier is used in standardization. Two or three position controls, or up to six alarm contacts are optional. Built-in fail-safe action is standard.

Your recording requirements can best be met with Thermo Electronic Instruments.

Write today for Catalog 66-F



Convenient access to all components provided by functional design.

Thermo Electric CO., INC. SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ontario

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NEW...
VIBRATING CAPACITOR
A vibrating-reed type capacitance modulator for use in measuring currents as low as 10 − 16 amperes.
Long term stability for process control. Drift ±0.2 millivolts per day, non-cum.
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PRESSURE GAUGES PERFORM WITH ACCURACY AND RELIABILITY **BEYOND** ALL PUBLISHED MIL SPECS.

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MACHINE-DIVIDED SCALES

Made with latest SIP Swiss Automatic Dividing Machines

LINEAR
Accuracy to ±5 microns (0.0002″)
CIRCULAR
Accuracy to ±5 seconds

Any scale pattern—Any line width—Any material

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PRECISION MACHINE-RULED MASTERS
For printed circuits, i.e., commutators, switches, and general circuitry

L. C. RENICK CO.
308 So. Salsipuedes St., Santa Barbara, Calif.
formerly Cicero, Illinois

CIRCLE 126 ON READER-SERVICE CARD

HIGH-TEMP CONNECTOR

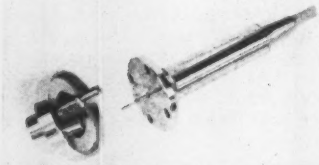
New line of Thermocouple Connectors with ceramic inserts withstands temperatures up to 1000°F and can

be used in power as well as thermocouple circuits. Presently available in five-, nine- and eleven-contact configurations for welded, soldered, or brazed connections for up to #14 wire.—*Harco Laboratories, Inc.*, 77 *Olive St., New Haven, Conn.*

CIRCLE 232 ON READER-SERVICE CARD

DISPLACEMENT TRANSDUCERS

New Models 580 and 581 Linear Displacement Transducers are primarily for use with Sanborn 150-, 350- and 850-Series carrier ampli-

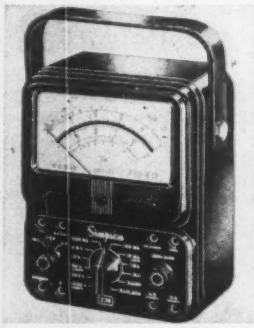


fiers, or 150-, 350- and 850-Series phase sensitive demodulator amplifiers. Both models have a maximum stroke of ±0.050″ (0.100″ total); 0.5% linearity; and operate from 5-v, 2400-cps excitation.—*Sanborn Co., Industrial Div.*, 175 *Wyman St., Waltham* 54, *Mass.*

CIRCLE 233 ON READER-SERVICE CARD

HIGH-ACCURACY VOM

New Model 270 Volt-Ohm-Milliammeter features d-c accuracy of 1½% full scale at 77°F, a mirror

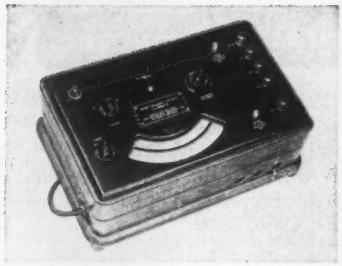


scale, ½% resistors, gold-bonded diodes, polarity switch, and knife-edge pointer.—Bulletin ST-301 A contains details.—*Simpson Electric Co.*, 5200 *West Kinzie St., Chicago* 44, *Ill.*

CIRCLE 234 ON READER-SERVICE CARD

R-F VOLTAGE CALIBRATOR

New Model RFVC Radio-Frequency Voltage Calibrator provides 4 true-rms voltage output ranges for VTVM calibrations between 2 mv and 3 v. Accuracy is 0.3% of full

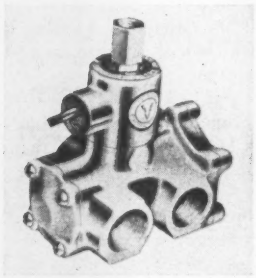


scale, and maximum frequency influence is ±0.2% from dc to 10 Mc.—2-page bulletin gives details.—*Sensitive Research Instrument Corp.*, 310 *Main St., New Rochelle, N. Y.*

CIRCLE 235 ON READER-SERVICE CARD

SOLENOID VALVES

New L3 Series of three-way Solenoid Valves for oil, air, water, vegetable and petroleum oils, inert gases, kerosene, gasoline, etc. are bubble-

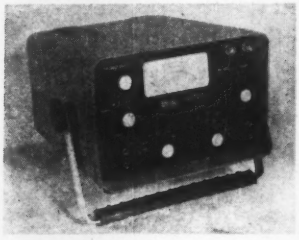


tight, compact, light, mount in any position directly to the line, and operate on a pressure differential of 5 to 150 psi. Available in ⅜", ½" and ¾" sizes.—*Skinner Electric Valve Div., Dept. LL69, 105 Edgewood Ave., New Britain, Conn.*

CIRCLE 236 ON READER-SERVICE CARD

WIDE-RANGE VOLTMETER

New series of R-2 Voltmeters measures a-c and d-c voltages from 1 mv to 1000 v full scale in 14 ranges,

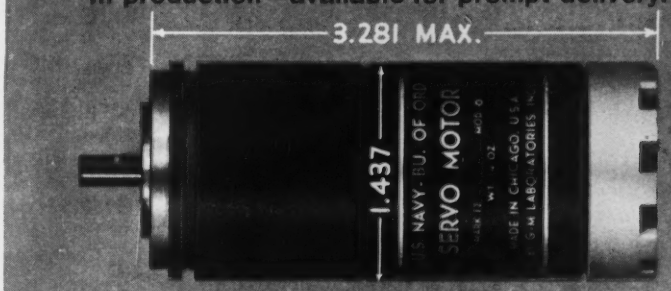


and midscale resistances from 10 ohms to 10 megohms in 7 decade ranges. Accuracy is better than 1% on dc; on ac better than 2%, from 20 cps to 100 kc; and 5%, from 10 cps to 1 Mc.—*Southwestern Industrial Electronics Co., Div. of Dresser Industries, Inc.*, 10201 *Westheimer Rd., P. O. Box* 13058, *Houston* 19, *Texas.*

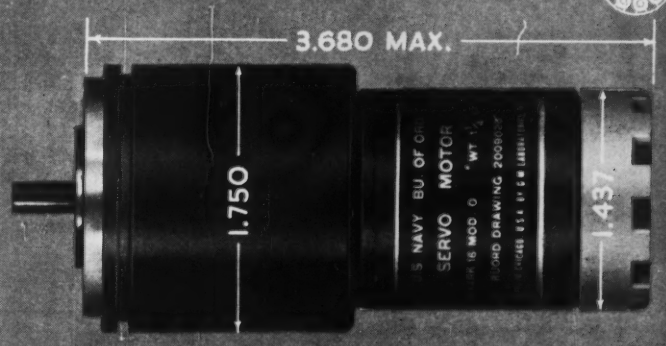
CIRCLE 237 ON READER-SERVICE CARD

GM TACHOMETER-GENERATORS

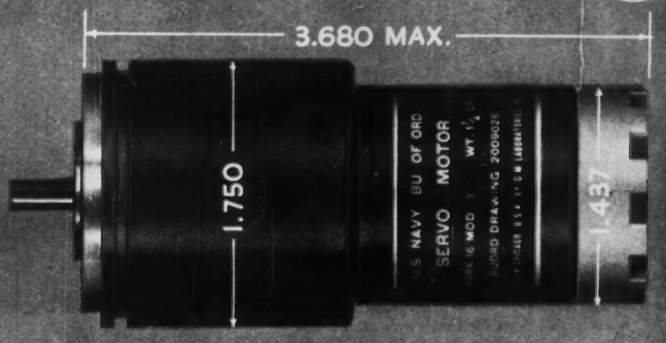
Built to all applicable Government Specifications.
In production—available for prompt delivery.



BuOrd Mark 12 Mod 0 SERVO MOTOR Tachometer Generator 115 volts / phase, 4500 RPM (min).



BuOrd Mark 16 Mod 0 SERVO MOTOR Tachometer Generator 115 volts / phase, 4500 RPM (min).



BuOrd Mark 16 Mod 3 SERVO MOTOR Tachometer Generator for transistor operation 115 volts fixed phase 36/18 volts control phase, 4500 RPM (min.)

GM
G-M Servo Motors
manufactured by the Components Division of
G-M LABORATORIES INC.
4316 N. Knox Avenue • Chicago 41

For complete information on these and all SERVO MOTORS, write for G-M PROCUREMENT SPECIFICATION NO. 665 and Catalogue

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The dial thermometer at its best
DISTANT READING
Something much finer in a dial thermometer: finer because it is the bourdon tube type of thermometer at its best...embodies the greater precision and lasting accuracy of the Marsh Pressure Gauge.
Both vapor tension and gas-filled types are available in either distant reading or rigid stem types. In the broad Marsh line you have a complete selection of temperature ranges, case sizes, styles, and finishes.
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Ask for the Thermometer Catalog
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CIRCLE 129 ON READER-SERVICE CARD

new plants and mergers

DU PONT COMPANY is building new laboratory and office facilities for its Mylar polyester film technical section adjoining its Circleville, Ohio, plant.

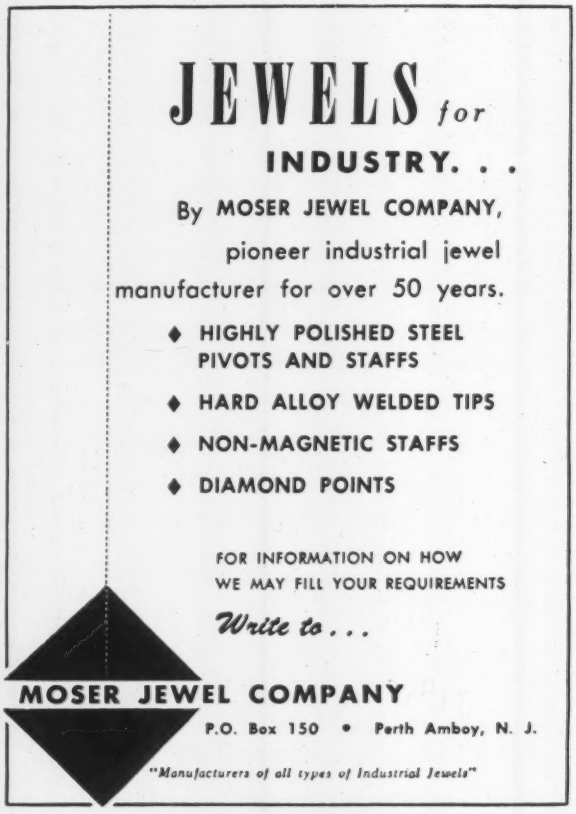
AMERICAN MACHINE AND METALS has purchased the assets of Automatic Devices Co., of Western Springs, Ill. and will operate it as its Automatic Devices Div.

PENBERTHY MFG. CO. soon will move from Detroit to new facilities at Prophetstown, Ill., and will be designated as Prophetstown Mfg. Div. of Buffalo-Eclipse Corp.

CHEMPUMP recently moved into new, larger quarters at Huntingdon Valley, a suburb of Philadelphia, and will be operated as the Chempump Div. of the Fostoria Corp.

U. S. RADIUM has completed a new addition to the plant and substantially doubled its capacity. Another facility has also been taken over which will provide an additional 25,000 sq ft of production area.

TEXAS INSTRUMENTS is expanding the Kentucky Plant of its Metals and Controls Div. by 9,600 sq ft which will increase by one third the manufacturing space of the 28,000-sq-ft plant.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ITEMLAB, INC. and **ITEMCO, INC.**, its parent organization, have voted a merger pending approval by stockholders and SEC.

FOXBORO COMPANY and RADIO CORP. OF AMERICA jointly announced that they "are combining instrumentation, process control, and digital computer know-how to supply industry its first completely-integrated computing control system." Under the arrangement Foxboro will act as manufacturer's representative for RCA's industrial computer products and provide its own specialized instrumentation and process information.

people in the news

PACKARD BELL ELECTRONICS announces that *Russell J. LeVesque* has been appointed manager of the printed circuit department of the Technical Products Division.

DAYSTROM INSTRUMENT DIV. announces appointment of *Richard E. Bennett* as plant manager; *Leslie E. Daniels* as assistant sales manager; and *Edgar G. Grant* as engineering manager.

BAILEY METER CO. announces appointment of *K. R. Dodson* as resident engineer in Corpus Christi, Texas.

CHART-PAK announces appointment of *A. Philip Sherburne* as general sales manager.

DUMONT LABS. announces appointment of *Robert W. Deichert* as engineering manager for Scientific Instruments of the Industrial Electronics Div.

CHARTS
for Recording Instruments

We offer to the Instrument Maker Charts for all methods of Recording: Pen, Ball Point, Electrical, Thermal, Pressure and Metallic Stylus.

Uniform accuracy is assured through the use of specialized equipment operated under controlled atmospheric humidity conditions.

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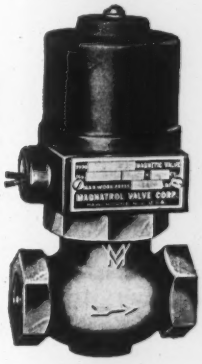
Flow Failures



Magnatrol
SOLENOID VALVES

Quick Operating *Non Sticking* *Tight Seating*

These three design advantages are your assurance against costly flow failures. Attain dependable, accurate, automatic or remote control of liquids or gases with **Magnatrol Valves**. Installed quickly and easily in connection with . . . flow-meters, thermostats, float and time switches. **Every Magnatrol Valve** is delivered to you—factory **tested**—guaranteed free from defects in material and workmanship.

Available in normally closed or normally open models. Pressure ranges from zero up to 300 PSI. Voltages to 575.

Catalog containing complete specifications mailed upon request.

Magnatrol **VALVE Corp.**
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Precision
HEAT MEASUREMENT
by
Dillon

- 12 Fah & Cen ranges for gases or liquids
- 1", 1 1/16", 2 5/16", 3", 5" head sizes
- Stem lengths from 2½" to 72"
- Straight form or angle form
- Choice of mounting nuts
- Pressure & moisture proof. Overheat protected.
- Corrosion resistant (bezels & stems made of 316 ss)
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YOURS FREE! Engineering catalog describing more than 100 models of Dillon Thermometers and quoting prices. Write **today!**

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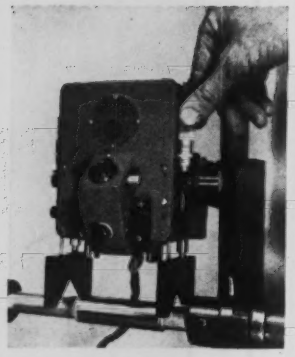

A TORQUEMETER WITHOUT SLIP RINGS

The PhotoStress Transducer

You can measure torque without attaching slip rings, without cutting into the shaft, yet obtain accuracies of better than ½% full-scale with long term stability with a PhotoStress Torquemeter Transducer. The Transducer measures torque optically, eliminating contact between Transducer and shaft; result—there is no limitation to shaft speed. Nor is there any limitation to shaft size (except for shafts as thin as fine wire). Readout is digital or in millivolts—depending on the recording method desired.

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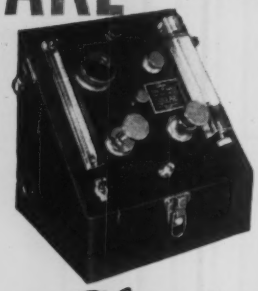
TAKE GUESSWORK OUT of DEW POINT READING with Alnor® DEWPOINTER



Anyone can quickly... accurately... read dew points with the Dewpointer. It is the only instrument that lets you see the fog in a sealed chamber under controlled conditions. Compare this fast, positive method with attempts made to tell exactly when fog forms on a mirrored surface. Completely self-contained, requires no external coolant or auxiliary apparatus ...operates on enclosed battery or AC. Available in three ranges for dew points between −20° F. and room temperature, from −80° to 0° F. and −80° F. to room temperature.

Send for Dewpointer bulletin. Tear out this ad and send on your letterhead to: Illinois Testing Laboratories, Inc., Room 518, 420 N. LaSalle St., Chicago 10, Ill.

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PEOPLE—CONTINUED

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Electronic Specialty

D. C. DUNCAN
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Clevite

J. H. HARRIS
Clevite

W. G. HOLZBOCK
Sanders

F. M. JENNER
Consolidated Vacuum

L. M. FAULKNER
Hagan

BURNDY CORP. has elected *Marvin Lee* president. He succeeds *Bern Dibner*, who was elected chairman of the board of directors.

ELECTRIC SPECIALTY CO. announces appointment of *William E. H. Reardon* as vice president and sales manager.

PACIFIC ELECTRONIC CONTROLS CORP., a wholly-owned subsidiary of Royal Industries, Inc., has named *Donald C. Duncan* president.

STROMBERG-CARLSON announces appointment of *Warren C. Dunn* as manager of marketing for Stromberg-Carlson, San Diego.

CLEVITE CORP. announces promotions for two top executives: *Curtis B. Hoffman*, general manager of Brush Instruments Div., has been elected Clevite's vice president-electronics, and *John H. Harris*, who was general manager of the Texas Div. has been named general manager of Brush Instrument.

SANDERS ASSOCIATES, INC. announce that *Werner G. Holzbock* has been appointed assistant manager of the Instrumentation and Control Systems Laboratory.

CONSOLIDATED ELECTRODYNAMICS CORP'S., Rochester Div., recently started operations as **CONSOLIDATED VACUUM CORP.**, a wholly owned subsidiary of CEC, with *Frank M. Jenner* as new president.

HAGAN CHEMICALS & CONTROLS, INC., announces that *L. M. Faulkner* has been named manager of sales—data processing, Controls Div. He will be responsible for the sales of Kybernetes data systems, computing, and temperature monitoring equipments.

INTERNATIONAL RESISTANCE CO. announces appointment of *Walter Ware Slocum* as president of the company.

CONTINENTAL SENSING, INC. announces appointment of *B. C. Davis* as vice president.

TATNALL MEASURING CO. has formed a new management team: *Dr. John H. Buck* has been appointed vice president and general manager; Frank Tatnall, founder of the company, is now vice president in charge of sales development; and three product managers have been named: *James E. Starr* for MetalFilm strain gages and transducers; *Dr. Felix Zandman* for Photostress, the new photoelastic stress analysis technique; and *Edward S. Bowkley* for Tatnall and Krouse testing machines.

NORTH SHORE NAMEPLATE's president *Eugene T. Turney, Jr.* was among eleven men who recently were honored by Free Enterprise Awards Association's American Success Story Awards for their achievements.

E. T. TURNEY, JR.
North Shore

R. L. YEAGER
Electronic Assoc.

ELECTRONIC ASSOCIATES, INC., has named *Robert L. Yeager* as general manager, standard products (analog computers, standard instruments and data processing equipments). Mr. Yeager is also Chairman of the Eastern Simulation Council.

SAMA announces that *Horace M. Byrnes* has been appointed executive secretary of the Recorder-Controller Section.

OPTICS

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COPPER
*CORNING 707
*CORNING 7052
CUPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM FERRITE
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
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CIRCLE 135 ON READER-SERVICE CARD

THE SPOT GALVANOMETER

Laboratory Accuracy . . . Shop Ruggedness

The Cambridge Spot Galvanometer provides a complete outfit—galvanometer, lamp and scale—in one self-contained plastic case. It is robust, has a stable zero and does not require accurate levelling. The sharply defined spot can easily be read at a distance. The lamp may be operated on A.C. service current or 4-volt battery. Sensitivity in mm. on scale is from 19, 30 and 170 per micro-ampere using coils of 20, 50 and 400 ohms respectively. Scale can be read to 0.2 mm. Send for Bulletin 271.

CAMBRIDGE INSTRUMENT CO., INC.

3554 Grand Central Terminal, New York 17, N. Y.

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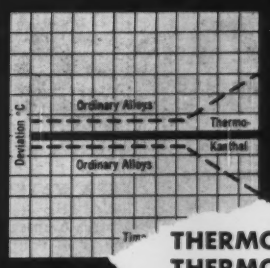

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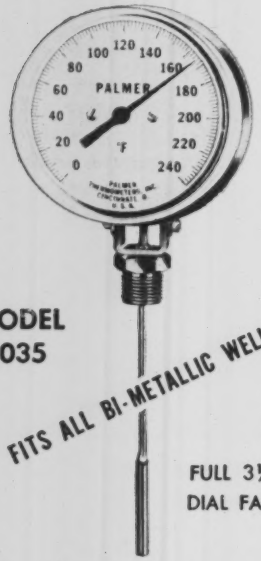

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new literature

CONTROL SYSTEMS

CONTROL SYSTEMS. 4-page Bulletin describes systems for full-scale automatic control in plants, refineries and pipelines.—Consolidated Systems Corp., a subs. of Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 238 ON READER-SERVICE CARD

CYCLE CONTROLLER. 12-page Bulletin C311 contains features, specs, dimensions, and functioning of Model CIC500 cycle controller for batch process operations.—Bristol Company, Waterbury 20, Conn.

CIRCLE 239 ON READER-SERVICE CARD

PRODUCTION CONTROL. 6-page Brochure H-201 graphically explains operation of Telecontrol for supervision and production activities from a central location.—Telecontrol Div., Hancock Industries, Inc., Jackson, Mich.

CIRCLE 240 ON READER-SERVICE CARD

RECORDERS AND CONTROLLERS. 4-page Bulletin No. 66 describes and gives applications for electronic indicating recorders and indicatng recorder-controllers.—Thermo Electric Co., Inc., Saddle Brook, N. J.

CIRCLE 241 ON READER-SERVICE CARD

INSTRUMENTATION AND CONTROL. 8-page condensed catalog lists Hays instruments for pressure, flow, temperature, level, and gas analysis; receivers; and the all-electric combustion control systems.—Hays Corp., Michigan City, Ind.

CIRCLE 242 ON READER-SERVICE CARD

FEED WATER CONTROL. 4-page Bulletin 531 describes two-element and single-element air-operated feed water control systems.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 243 ON READER-SERVICE CARD

PRESSURE, VACUUM WEIGHT, ACCELERATION

MULTI-POINTER INDICATOR. 4-page Product Specification P11-1 illustrates and describes Mini-Line multi-point indicators for pressure, vacuum, temperature, etc.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 244 ON READER-SERVICE CARD

VACUUM EQUIPMENT. 16-page product summary and price list classifies vacuum equipment and components by type and code number.—NRC Equipment Corp., 160 Charlemont St., Newton 61, Mass.

CIRCLE 245 ON READER-SERVICE CARD

PRESSURE PICKUP. 2-page Bulletin 1620 describes Type 4-326 pressure pickup capable of absolute and gage measurement to 10,000 psi.—Consolidated Electrodynamics Corp, 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 246 ON READER-SERVICE CARD

WEIGHING SYSTEMS. Series of four 4-page fact folders containing basic information form a convenient means of collecting information on industrial weighing systems.—A. H. Emery Co., New Canaan, Conn.

CIRCLE 247 ON READER-SERVICE CARD

VACUUM TECHNOLOGY. 4-page issue of "Duo-Seal Digest," Vol. 2/No. 1 contains digests of 8 magazine articles (including ICS) pertaining to vacuum technology.—W. M. Welch Mfg. Co., 1515 Sedgwick St., Chicago 10, Ill.

CIRCLE 248 ON READER-SERVICE CARD

PRESSURE SCANNER. 2-page Bulletin 110 contains description; mechanical, electrical, and pressure details; and specs of Model SP-105 pressure scanner.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 249 ON READER-SERVICE CARD

BAGGING SCALE. 6-page Bulletin 0156A describes the GA-38 automatic bagging scale for high-speed loading of 25, 50 and 100-pound bags in feed mills.—Richardson Scale Co., Clifton, N. J.

CIRCLE 250 ON READER-SERVICE CARD

ENGINE PERFORMANCE METER. 2-page Bulletin K15A describes the Korfund Pi-Meter, a direct-reading performance meter for diesel, gasoline, natural gas, and steam engines. —Korfund Co., Inc., 48-355 32nd Pl., Long Island City, 1, N. Y.

CIRCLE 251 ON READER-SERVICE CARD

DISTILLATION EQUIPMENT. 16-page Bulletin 3-1 explains high-vacuum distillation and the equipment used such as pot stills, molecular stills and centrifugal molecular stills.—Consolidated Electrodynamics Corp., Rochester Div., 1775 Mount Read Blvd., Rochester 3, N. Y.

CIRCLE 252 ON READER-SERVICE CARD

ACCELEROMETERS. Three 2-page bulletins contain features and specs of the Models 50X2, 300 and 301, and 402 and 403.—Columbia Research Labs., McDade Blvd. and Bullens Lane, Woodlyn, Penna.

CIRCLE 253 ON READER-SERVICE CARD

FLOW, PUMPS, TEMPERATURE

TURBO-METER. 12-page Bulletin OG-417 describes the Turbo-Meter a high-capacity meter for use in petroleum pipelines.—Rockwell Mfg. Co., Meter and Valve Div., 400 N. Lexington Ave., Pittsburgh 8, Pa.

CIRCLE 254 ON READER-SERVICE CARD

PROPORTIONING PUMP. 2-page bulletin 1107-20-1 describes plunger-type, small-capacity proportioning pump for chemicals used in treating of small low-pressure boilers.—B-I-F Industries, Inc., 345 Harris Ave., Providence, R. I.

CIRCLE 255 ON READER-SERVICE CARD

POSITIVE-DISPLACEMENT METERS. 20 page Bulletin 43 describes Niagara

Industrial Liquid Meters.—Buffalo Meter Co., Inc., 2929 Main St., Buffalo 14, N. Y.

CIRCLE 256 ON READER-SERVICE CARD

ELECTRONIC FLOW MEASURING SYSTEMS. 4-page Bulletin 1388 describes automatic channel selecting flow measurement system for range ratios up to 1:1000.—Cox Instruments Div., George L. Nankervis Co., 15300 Fullerton, Detroit 27, Mich.

CIRCLE 257 ON READER-SERVICE CARD

THERMOCOUPLES. 52-page Catalog EN-S2 offers complete information about L&N's full line of thermocouples, thermocouple components, and accessories.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Penna.

CIRCLE 258 ON READER-SERVICE CARD

ENVIRONMENTAL EQUIPMENT. 6-page folder illustrates and specifies environmental chambers and manufacturing facilities.—Itemco, Inc., 18 Beechwood Ave., Port Washington, N. Y.

CIRCLE 259 ON READER-SERVICE CARD

VALVES

VALVE POSITIONERS. 4-page bulletin illustrates and highlights FultroMatic pneumatic controller-positioner-valve, FultroLectric electric positioner, and FultroPilot pressure and temperature pilot controller.—Robertshaw-Fulton Controls Co., Fulton Sylphon Div., Knoxville 1, Tenn.

CIRCLE 260 ON READER-SERVICE CARD

CONTROL VALVE. 2-page catalog sheet describes the model 235-1 adjustable-cam, lever-operated control valve.—Atlas Valve Co., 280 South St., Newark, N. J.

CIRCLE 261 ON READER-SERVICE CARD

TIME, COUNT

GEARED COUNTER. 4-page data sheet and application guide describes operation, uses and modification available on a new line of high-speed, quick-reset geared counters.—Veeder-Root Inc., Hartford 2, Conn.

CIRCLE 262 ON READER-SERVICE CARD

COUNTING UNITS. 4-page bulletin contains construction data, operating instructions, electrical data, sketches, and illustrations of Sodeco single-decade counting units, Type 1TD.—Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y.

CIRCLE 263 ON READER-SERVICE CARD

TIME RELAY. 4-page Bulletin SR-10 describes and tabulates specs of Dial Head Agastat time relays.—AGA Div., Elastic Stop Nut Corp. of America, Elizabeth, N. J.

CIRCLE 264 ON READER-SERVICE CARD

ELAPSED TIME INDICATOR. 2-page Bulletin 5001 describes the physical and electrical characteristics of the WT-1 subminiature elapsed time indicator.—Waltham Precision Instrument Co., 221 Crescent St., Waltham 54, Mass.

CIRCLE 265 ON READER-SERVICE CARD

INSTRUMENT COUNTERS. Two 2-page catalogs illustrate and describe 2 new lines of precision instrument counters.—Chicago Dynamic Industries, Inc., Precision Products Div., 1725 Diversey Blvd., Chicago 14, Ill.

CIRCLE 266 ON READER-SERVICE CARD

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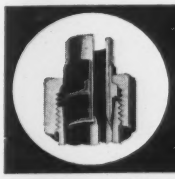

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CIRCLE 145 ON READER-SERVICE CARD

HIGH-INTENSITY STROBOSCOPE. 4-page Bulletin 780 gives specs, description, and uses of Model 510-A1 high-intensity stroboscope for speeds from 60 rpm up to 15,000 rpm, manufactured by Electronic Brazing Co., Montclair, N. J.—Herman H. Sticht Co., Inc., 27 Park Place, New York 7, N. Y.

CIRCLE 267 ON READER-SERVICE CARD

AIR

AIR DRYER. 4-page bulletin describes completely automatic Budget Air Dryer.—Pittsburgh Lectrodryer Div., McGraw-Edison Co., P. O. Box 1766, Pittsburgh 30, Pa.

CIRCLE 268 ON READER-SERVICE CARD

COMPRESSED AIR DATA. 16-page Form 1548 contains fundamentals on compressed air; and descriptions, terminology, and pointers on selection of air compressors.—Ingersoll-Rand 11 Broadway, New York 4, N. Y.

CIRCLE 269 ON READER-SERVICE CARD

DATA HANDLING

MAGNETIC TAPE PRODUCTS. Five 2-page bulletins (1592 thru 1595, and 1957) in folder describe complete line of miniature, lightweight amplifiers and power supply for magnetic tape recording.—Data Tape Div., Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 270 ON READER-SERVICE CARD

DATA TRANSLATORS. 8-page quick-reference catalog defines the term "record reader" and discusses maker's

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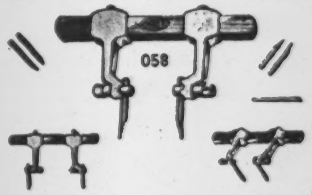

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CIRCLE 144 ON READER-SERVICE CARD

NEW LITERATURE

various types of record readers.—Benson-Lehner Corp., 11930 West Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 271 ON READER-SERVICE CARD

MEMORY CORE TESTER. 4-page Bulletin 59-A describes the React automatic core tester, a high-speed magnetic memory core analyzer, and emphasizes the modular test system design approach.—Rese Engineering, Inc., 731 Arch St., Phila. 6, Pa.

CIRCLE 272 ON READER-SERVICE CARD

AN/DIG RECORDER. 8-page Catalog 35-1541 describes shaft-input device that converts and records analog values in digital binary-decimal punched tape form.—Fischer & Porter Co., 151 Jacksonville Rd., Hatboro, Penna.

CIRCLE 273 ON READER-SERVICE CARD

DIGITAL PRINTERS. 8-page Bulletin 671-71-3 discusses applications, features, and specifications of solenoid-actuated digital printers.—Victor Adding Machine Co., 3900 N. Rockwell St., Chicago 18, Ill.

CIRCLE 274 ON READER-SERVICE CARD

GAGING, TESTING

TEST EQUIPMENT FOR SERVOS. 25-page manual is a comprehensive report on the latest techniques of control synchro and control resolver testing.—Theta Instrument Corp., 48 Pine St., East Paterson, N. J.

CIRCLE 275 ON READER-SERVICE CARD

MICROMETERS. 4-page brochure covers precision motorized and manually-operated dead weight micrometers for measurement of paper, film, foil, and rubber sheet materials.—Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y.

CIRCLE 276 ON READER-SERVICE CARD

THE INTERNATIONAL INCH. 8-page booklet discusses problems a manufacturer can be expected to encounter as a result of America's change-over to the International Inch as of July 1, 1959.—Pratt & Whitney Co., Inc., Charter Oak Blvd., West Hartford 1, Conn.

CIRCLE 277 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

PULSE HEIGHT ANALYZER. 4-page Form 3021-9 describes the Model PHA-120, a 100-channel pulse height analyzer with 20 channel storage.—Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 278 ON READER-SERVICE CARD

MULTIPLIER-DIVIDER. 2-page leaflet contains general specifications, and some application notes on the multiplier-divider, Model K5-M.—George A. Philbrick Researches, Inc., 285 Columbus Ave., Boston 16, Mass.

CIRCLE 279 ON READER-SERVICE CARD

METER RELAY. 4-page Bulletin S-2, describes a new continuous reading meter-relay (CRMR).—Assembly Products, Inc., Chesterland, Ohio.

CIRCLE 280 ON READER-SERVICE CARD

PRINTING DEMAND METERS. 8-page Bulletin GEA-6892 describes maker's redesigned printing demand meters for recording of loads.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 281 ON READER-SERVICE CARD

ELECTRONIC VOLTMETER. Brochure BK2409 contains information on electronic voltmeter which measures either true rms, peak, or average values of voltage over the frequency range from 2 to 200,000 cps.—B & K Instruments, Inc., 3044 West 106th St., Cleveland 11, Ohio.

CIRCLE 282 ON READER-SERVICE CARD

STATISTICAL EVALUATION OF METER ACCURACY. 8-page Bulletin GEA-5585A provides a method of obtaining logical and useful conclusions from studies of watt hour meter accuracy data.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 283 ON READER-SERVICE CARD

INFRARED DATA. Folder contains three 2-page bulletins on bias supply, black body with temperature controller, and detector test console, respectively.—Infrared Standards Lab., 10555 Magnolia Ave., Riverside, Calif.

CIRCLE 284 ON READER-SERVICE CARD

RMS VOLTMETER. 2-page Bulletin 55 and 4-page Bulletin 42 contain specs and technical data, respectively, of random signal meter Model TBM-2.—Flow Corp., 85 Mystic St., Arlington, Mass.

CIRCLE 285 ON READER-SERVICE CARD

DIFFERENTIAL AMPLIFIER. Wall-size folder contains illustrations and highlights of wide-band, low-level differential d-c amplifier Model DA-102.—Epsco, Inc., Instruments and Equipment Div., 275 Massachusetts Ave., Cambridge, Mass.

CIRCLE 286 ON READER-SERVICE CARD

VECTORLYZER. 2-page bulletin contains description and specs of new instrument, Type 202, for measuring vector relations of alternating voltages.—Ad-Yu Electronics Lab., Inc., 249 Terhune Ave., Passaic, N. J.

CIRCLE 287 ON READER-SERVICE CARD

ELECTRIC MACHINERY. 4-page Form DC459 describes custom-designed systems approach to power converting systems and complete line of d-c generators.—Kato Engineering Co., Mankato, Minn.

CIRCLE 288 ON READER-SERVICE CARD

MISCELLANEOUS

DRAIN OR SAMPLING VALVES. 2-page Catalog 355, gives details of Jerguson No. 23 drain or sampling valve.—Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

CIRCLE 289 ON READER-SERVICE CARD

MINIATURE SWITCHES. 2-page Bulletin L-52S illustrates and describes two new switches: a printed-circuit switch, and a dual concentric-shaft switch.—Shallcross Mfg. Co., Preston St., Selma, N. C.

CIRCLE 290 ON READER-SERVICE CARD

CHROMATOGRAM SCANNER. 2-page Bulletin 160 describes Scanogram II, an automatic windowless chromatogram scanner for counting Tritium, Carbon-14, and Sulfur-35.—Atomic Accessories, Inc., 244-02 Jamaica Ave., Bellerose 26, N. Y.

CIRCLE 291 ON READER-SERVICE CARD

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ELECTRONIC TRAINING AID. 2-page Bulletin 901-B describes how the Model 23 circuit board can be used in the classroom to allow students to build and rebuild circuits using standard components.—Plastic Associates, 185 Mountain Rd., Laguna Beach, Calif.

CIRCLE 292 ON READER-SERVICE CARD

EQUIPMENT CONTROL CONNECTORS. 12-page Bulletin 372 gives complete information on equipment control connectors.—Joy Mfg. Co., Electrical Products Div., 1201 Macklind Ave., St. Louis 10, Mo.

CIRCLE 293 ON READER-SERVICE CARD

SEMICONDUCTOR RELAYS. 2-page Engineering Bulletin 65, describes semiconductor relays for high-speed signalling or data current control.—Rixon Electronics Inc., 2414 Reedie Dr., Silver Spring, Md.

CIRCLE 294 ON READER-SERVICE CARD

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ADVERTISERS INDEX

This index is published as a service. Every care is taken to make it accurate, but I&CS assumes no responsibility for errors or omissions.

Ad-Yu Electronics Labs., Inc. 1596
Allied Radio 1588
American Chain & Cable Company, Inc. Helicoid Gage Division 1579
American Machine & Metals, Inc., United States Gauge Division 1557
American Meter Company, Incorporated 1565, 1571
American Meter Company, Mechanical Components Dept. 1580
Assembly Products, Inc. 1561
Audio Devices, Inc. 1503
Automatic Timing and Controls, Inc. 1562

B & H Instrument Co., Inc. 1577
B-L-H: Electronics & Instrumentation Div. 1568, 1570
Bailey Meter Company 1478
Barksdale Valves 1490
Bayley Instrument Co. 1593
Bendix Aviation Corporation 1500
Berkeley Division, Beckman Instruments, Inc. 1551
Breeze Corporations, Inc. 1461
Bristol Company 1471, 1563
Brooks Rotameter Company 1565
Brush Instruments Division of Clevite Corporation ..... Inside Back Cover
Budd Company 1590

Cambridge Instrument Co., Inc. 1591
Clare & Co., C. P. 1464, 1465
Clary Corporation 1575
Clevite Corporation, Brush Instruments Division ..... Inside Back Cover
Cohu Electronics, Inc. Kin Tel Division 1467
Colvin Laboratories, Inc. 1505
Computer Control Co., Inc. 1498
Computer-Measurements Company 1455
Computer Systems, Inc. 1516
Conax Corp. 1574
Concord Controls Inc. 1580
Conoflow Corporation 1497
Consolidated Electrodynamics 1479
Cox Instrument Division, Nankervis Company, George L. 1572
Crawford Fitting Company 1512
Crescent Insulated Wire & Cable Co., Inc. 1506

Dahl Company, Inc., George W. 1566
Daystrom Systems Division of Daystrom, Inc. 1510
DeZurik Corporation 1508
Dillon & Company, Inc., W. C. 1589
Du Mont Laboratories, Inc., Allen B. 1470

Edison Industries, Inc., Thomas A., Instrument Division 1514, 1515
Electronic Associates, Incorporated 1546
Eppley Laboratory, Inc. 1468
Esterline-Angus Company, Inc. 1582

Fairchild Camera and Instrument Corporation 1570, 1576
Farris Engineering Corp. 1581
Fenwal Incorporated 1469
Flodar Corp. 1593
Foxboro Company 1484
Franklin Electronics, Inc. 1492, 1493
Fulton Sylphon Div. 1460

G-M Laboratories, Inc. 1587
GPE Controls, Inc. ..... Inside Front Cover
GPS Instrument Co. Inc. 1549
General Controls ..... Outside Back Cover
General Electric Company 1595
Glassco Instrument Company 1586
Gow-Mac Instrument Co. 1584
Greiner Co., Emil 1511
Gubelman Charts Incorporated 1589

Hankison Corp. 1489
Hays Corporation 1457
Heise Bourdon Tube Company, Inc. 1569
Helicoid Gage Division American Chain & Cable Company, Inc. 1579
Hoke Incorporated 1567
Howell Instrument Company 1505
Hydromatics, Inc. 1459

Illinois Testing Laboratories, Inc. 1590
Industrial Electronics Engineers, Inc. 1454
Instrulab, Inc. 1593
International Resistance Company Computer Components Division 1576

Jones Optical Works, A. D. 1591

Kanthal Corporation 1591

Laboratory for Electronics, Inc. 1504
Leslie Co. 1473
Lewis Engineering Co. 1451
Liquidometer Corp. 1563
Lockheed Electronics & Avionics Div. 1495
Lynn, Robert M. 1593

Magnatrol Valve Corp. 1589
Manning, Maxwell & Moore, Inc. 1477, 1496, 1507, 1518
Marsh Instrument Co. 1588
Marshalltown Mfg. Co. 1563
Marx Co., Clarence J. 1593
Mercoid Corporation 1578
Midwestern Instruments 1573
Mine Safety Appliances Company 1491
Minneapolis-Honeywell 1480, 1560
Moeller Instrument Company 1472
Moore & Company, Samuel 1462
Moser Jewel Company 1588

NJE Corporation 1571
Nankervis Company, George L., Cox Instruments Division 1572
Nash Engineering Company 1483
North American Van Lines, Inc. 1517
Norwood Controls 1595

Offner Electronics 1564

Palmer Thermometers, Inc. 1592
Partlow Corp. 1475
Philbrick Researches, Inc., George A. 1553
Preis Engraving Machine Co., H. P. 1582
Pyro Service Co. 1593

Radio Frequency Laboratories, Inc. 1456, 1566
Renick Co., L. C. 1586
Robbins Aviation, Inc. 1482
Rockwell Mfg. Company 1486, 1487
Royal McBee Corporation 1555

Sanborn Company 1502
Scherr Co., Inc., George 1574
Scientific Instrument Company 1594
Sensitive Research Instrument Corp. 1452
Shore Inst. & Mfg. Co., Inc. 1584
Simplatrol Products Corp. 1561
Sprengnether Instrument Co., Inc. W. F. 1574
Stevens-Arnold Incorporated 1586
Stromberg-Carlson, Div. of General Dynamics 1509, 1556
Superior Tube Company 1481
Swartwout Co. 1485
Synchro-Start Products, Inc. 1574

Tally Register Corporation 1558
Technique Associates 1596
Teletype Corporation 1513
Thermo Electric Co., Inc. 1585
Trans-Sonics, Inc. 1458
Trimount Instrument Co. 1494
Trinity Equipment Corporation 1482

Unertl Optical Co., John 1582
United Electric Controls Company 1545
United States Gauge Division of American Machine & Metals, Inc. 1557
United States Motors Corporation 1499

Valcor Engineering Corp. 1474
Varian Associates 1558
Veeder-Root Inc. 1476
Video Instruments Co., Inc. 1568
Voltron Products 1559

Wallace & Tiernan Incorporated 1583
Weston Instrument Div. of Daystrom, Inc. 1474, 1561
Westronics Incorporated 1564
Worley Jewel Co., John 1584

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0.0001 cps to 500 mc.
Accuracy 0.5
Direct Reading in Degrees.

DELAY LINES

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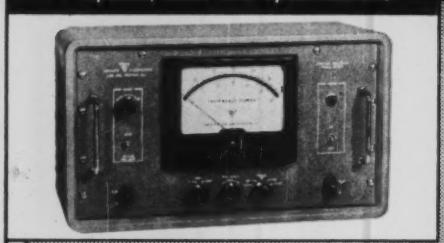

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Type 405 Series — 1 cps to 500 kc.
Accuracy — 0.25°.
Type 205A1-A2 — 100 kc to 15 mc.
Accuracy — 0.05°.
Type 205B — 15 mc. to 500 mc.
Accuracy 0.05°.
Type 202 — 20 cps to 150 kc.
1° full scale sensitivity
Accuracy — 0.05° or 2%
Phase Angle Counters: 0.0001 cps to 1000 cps.
Accuracy — 0.5°.

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This index is published as a service. Every care is taken to make it accurate, but I&CS assumes no responsibility for errors or omissions.

Accelerometer, 230
Air Dryer, Filter, 34, 73, 196, 227
Amplifier, DC, 78, 87, 94
An/Dig Converter, 38, 205, 216
Annunciator, 59

Battery, 214
Bellows, 11, 163
Bourdon Helix, 125

Cable, 2
Chart Changer, 208
Chart Drive, 33, 99
Charts, 85
Computer, Analog, 60, 63, 65
Computer, Digital, 45, 67, 161
Connectors, 232
Contact Meter, 221
Counters, 24

Data Display, 49
Data Logging, 58
Dew Point, 134
Digital Instruments, 37
Digital Readout, 4
Digital Recording Systems, 37
Displacement Trans., 107, 233

Electrical Inst. Calib., 6
Electronic Equipment, 129
Engine Controls, 103
Engraver, 116
Environmental Test, 177

Feeder, 119
Flowmeter, 88, 199
Flowmeter Calibrator, 100, 173
Flow Snubber, 157
Frequency Converter, 229
Function Generator, 217

Galvanometer, 136, 225
Gas Anaylzer, 36, 120
Glove Box, 56

Hardness Tester, 122, 211
Hydrometer, 19

Ionization Chamber, 212
ITV, 184, 223

Jewel, 121, 130

Keyboards, 113

Leak Detector, 178
Level, 20, 84, 200, 201
Level Switch
Load Cells, 93, 220

Magnetic Tape, 48
Manometer, 118

Optical Parts, 117, 135
Oscilloscope, 168, 172
Oxygen Analyzer, 7

Panel Meter, 179
Photoelectric Controls, 160
Pilot Controller, 10
Pneumatic Trans., 62
Potentiometers, 50, 156
Power Isolator, 219
Power Supplies, 98, 192
Pressure Gages, 25, 69, 83, 95, 111, 218
Pressure Scanner, 59
Pressure Snubber, 203
Pressure Switches, 35, 110, 198
Pressure Transducers, 27, 72, 206, 207
Printer, Electronic, 54
Printer, High Speed, 5, 58, 106, 193
Pulse Generator, 162
Process Control, 18, 32

Racks, 187
Receiver Indicator, 167
Record Camera, 17, 97, 108
Recorders, 47, 71, 86, 87, 89, 115, 123, 148, 195, 202
Relays, 13, 68, 181, 183, 226

Scales, 126
Scintillation, 182, 188
Seismograph, 105
Shaft-to-Digital Encoders, 205
Shipping, Uncrated, 61
Specific Gravity, 112, 154
Standard Cells, 15
Standby Power, 44
Strain Gage Cement, 209

Tachometer Generator, 127
Tape Programmer, 228
Tape Reader, 74
Tape Recorder, 40
Telemeter, 55, 58, 90
Temperature Controller, 23, 70, 222, 224
Temperature Monitoring, 16, 59, 147, 191
Thermistor, 166, 169
Thermocouple, 30, 137
Thermocouple Gland, 102, 165
Thermocouple Well, 28
Thermometers, 8, 41, 128, 169
Timer, 82, 158, 171, 194
Timer, Electronic, 170, 213
Toolmaker's Microscope, 104
Torque Meter, 133
Transmitting Pot., 215
Tube Fittings, 57
Tubing, Capillary, 29
Tubing, Harness, 12, 51

Valve Actuator, 1, 149, 159
Valve, Ball, 9, 204
Valve, Control, 42, 53
Valve Manifold, 91
Valve Relief, 114
Valve, Servo, 101
Valves, Small, 52, 73, 210, 231
Valves, Solenoid, 21, 92, 131, 236
Valve Test, 186
Vibrating Capacitor, 124
Voltage Comparator, 235
Voltmeter, 109, 189, 190, 197, 235, 237
VOM, 234

Weight, 96, 155, 180, 220
Wire Fault, 185

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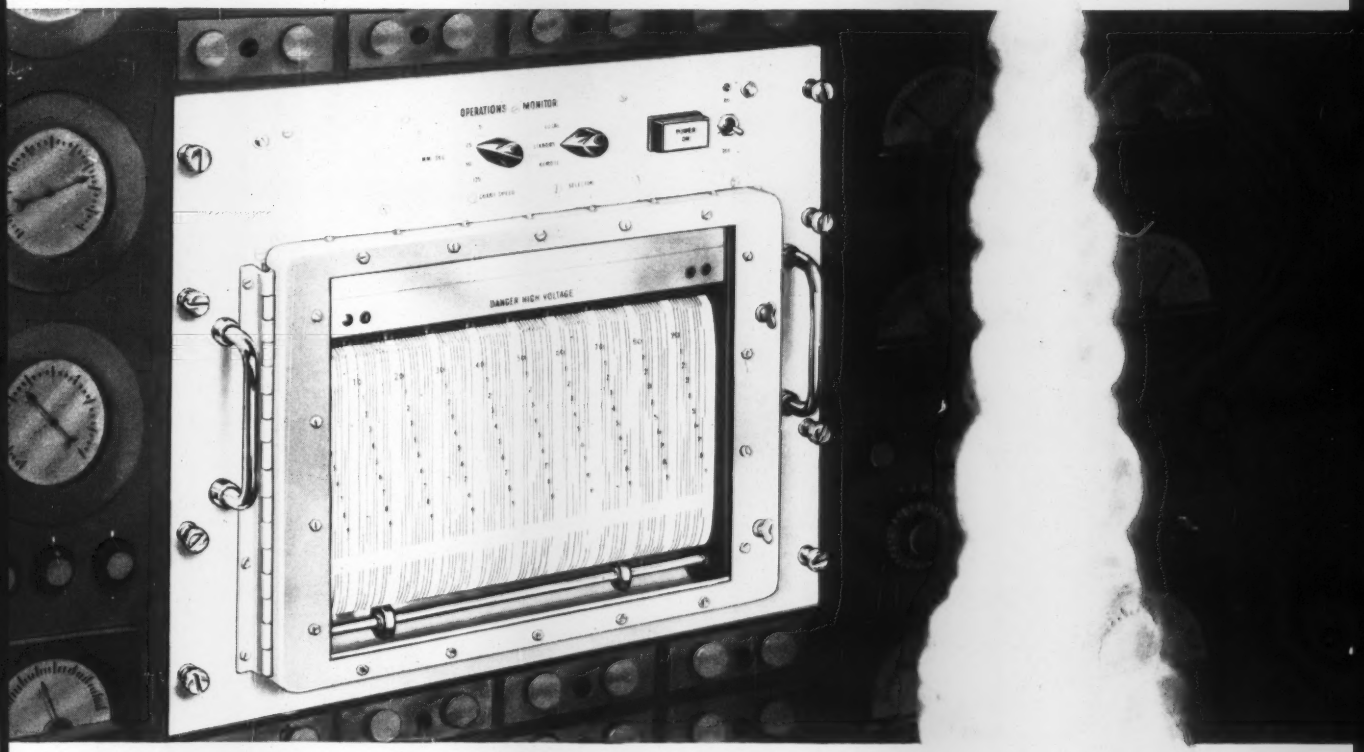

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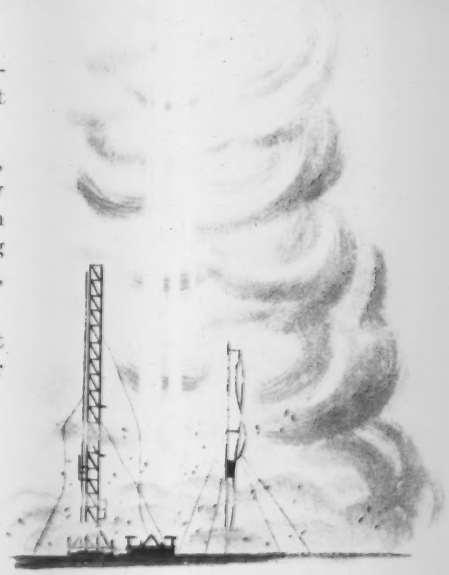

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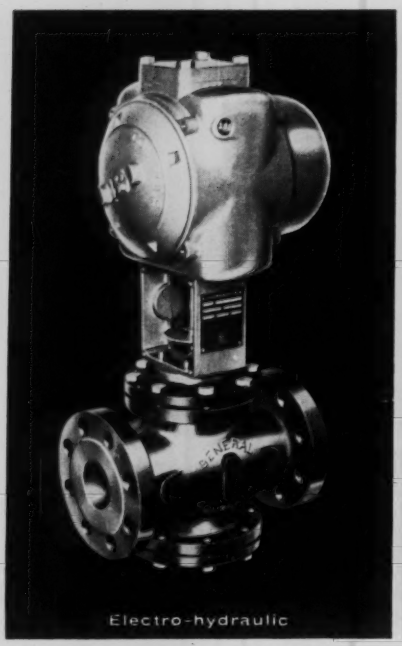

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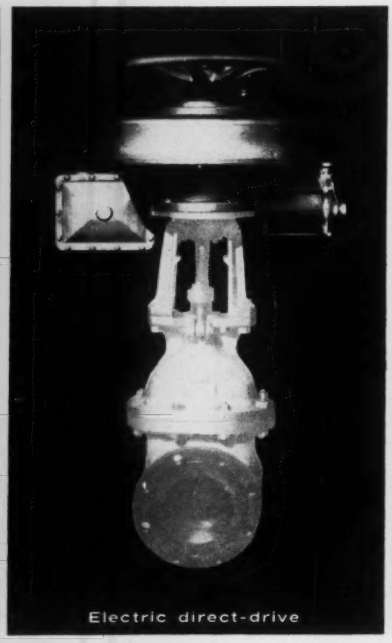

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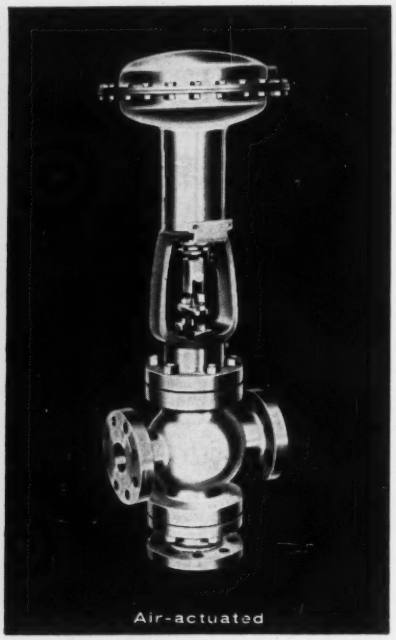

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